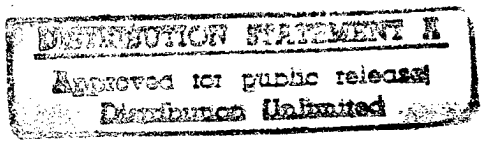
JPRS-UMS-89-001
4 APRIL 1989

JPRS Report



Science & Technology

Materials Science

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UDC 539.43

Development of Fatigue Cracks

18420046a Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 15 Jan 88) pp 9-18

[Article by Ya. Nemets, Prague, CSSR]

[Abstract] The history of fracture mechanics is briefly outlined. Directions for future study of the physical mechanisms of fracture are suggested: 1) In microscopic volumes of materials, one must orient oneself toward the accumulation of dislocations and structural damage to materials. These accumulations of microdefects have their developmental regularities and laws of motion, leading to the rotation of microscopic volumes of material and creation of tunnels for movement and development of noncontinuity, presenting hardening barriers to this movement. 2) The surface layer of a material must be studied as a special medium, considering the intermediate volume, resistant in plastic deformation, usually developing as zones with a certain periodicity. 3) The regulation of fatigue crack development in microscopic volumes of bodies must be established. The growth curve of a fatigue crack is analyzed, using the concept of accumulation of damages in local cyclically loaded volumes of the material to predict the moment of formation of a fatigue crack. Developing cracks are subdivided into small and large cracks, with dimensions comparable to or greater than the structural components of the material. Experimental results obtained by the author and others allow the rate of crack growth in structural ferrite-pearlite steels to be expressed in a way allowing a quantitative estimate of the service life of machine parts. Experiments are necessary, but must be planned on the basis of the manufacturing technology of parts and their usage conditions, considering the great experience gained in studying the fatigue life of actual parts in use. Equations are presented for the estimated fatigue life of parts and the reduction in fatigue life caused by stress concentrators. References 9: 2 Russian, 1 Western, 6 East European.

UDC 669.715:620.172.246

Kinetics and Fractography of Fatigue Fracture of VAL15 Alloy With Variable Cycle Asymmetry

18420046b Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 8 Jul 86) pp 31-34

[Article by G. V. Klevtsov, N. S. Postnikov, A. G. Zhizherin, I. S. Gotsev and Zh. T. Bakirov; Frunze Polytechnical Institute; All-Union Aviation Materials Scientific Research Institute]

[Abstract] A study is made of the kinetics and mechanism of fatigue fracture of VAL15 alloy with variable asymmetry of the loading cycle. The new high-strength cast alloy VAL15 is an Al-Cu-Mn-Si-Cd alloy with tensile strength 400 MPa, yield point 300 MPa, and reduction area 6 percent. Fatigue testing was performed at 10 Hz with loading cycle asymmetry coefficients of 0.1, 0.5 and 0.7. X-ray structural analysis of fracture surfaces indicates that as crack length increases the width of the diffraction line representing the distortion of the crystalline structure of the material on the fracture surface also increases. The degree of distortion of the crystalline structure of the material under various conditions of asymmetry correlates more with K_{max} than with ΔK. As the ductility of fracture increases, the surface microrelief of fatigue fractures changes from microspalling to honeycomb microrelief which depends more on K_{max} than ΔK, regardless of load cycle asymmetry. References 3: all Russian.

UDC 546.281'261+621.794

Silicon Carbide Strength Estimation in Axial Compression and Bending After Chemical Treatment and Application of Hard Coating

18420046d Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 15 Apr 87) pp 54-59

[Article by V. A. Bushlov, O. B. Dashevskaya, A. A. Umiskiy, V. A. Kolzunov, A. K. Tsvetnikov, O. N. Tsybulskaya, T. Yu. Nazarenko, V. M. Dolgoruk and G. M. Okhrimenko; Strength Problems Institute, Ukrainian Academy of Sciences; Chemistry Institute, Far Eastern Department, USSR Academy of Sciences]

[Abstract] An estimate is presented of the strength of rectangular silicon carbide specimens exposed to positive and negative stresses after etching in hydrogen fluoride and application of metal coatings to the lateral surfaces. The specimens were treated with anhydrous hydrogen fluoride at 268-278 K, followed by application of hard coatings of aluminum, nickel, copper and titanium nitride. It was found that treatment with hydrogen fluoride did not significantly influence compressive or bending strength. Application of metal coatings increased bending strength by 5-15 percent. Metal coatings did not cause a significant increase in compressive strength. References 15: 14 Russian, 1 Western.

UDC 620.171:621.789

Study of Residual Stresses in Pressed Bars of High-Strength Structural Steel

18420046e Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 16 Jun 86) pp 103-106

[Article by Ye. V. Polyakov and V. V. Davydov, High Pressure Physics Institute imeni L. L. Vereshchagin]

[Abstract] A study is made of the distribution of residual macroscopic stresses in cold pressed specimens of type 30KhGSN2A steel. Axial residual stresses were determined in deformed specimens by longitudinal turning of cylinders. It was found that 6 percent deformation of high-strength steel by drawing through a die with relatively short calibrating belt and KTIOL-15 lubricant caused tensile axial residual stresses on the surface of the specimen. Die geometry influenced the residual stresses strongly, entry cone angles of 20° producing stresses of up to 2370 MPa. Great friction yielded compressive residual stresses on the surface of the specimens. There is a near linear relationship between

surface hardness and residual stresses, so that measurement of surface hardness can yield a qualitative estimate of the magnitude and direction of compressive stresses just under the surface. References 4: 3 Russian, 1 Western.

UDC 669.078.456.78

Laser Diffractometry of Fatigue Fracture Surface Under Cyclical Loading

18420046f Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 23 Oct 86) pp 107-110

[Article by A. V. Matokhin, V. V. Yudin, G. V. Matokhin, T. Yu. Yakovleva and A. V. Khlamenok; Far Eastern Polytechnical Institute imeni V. V. Kuybyshev; Strength Problems Institute, Ukrainian Academy of Sciences]

[Abstract] A method is suggested for statistical processing of fatigue fracture surface images in which the entire process of generating quantitative data is broken down into three main stages: 1) production of the fractograms themselves; 2) first level statistical analysis, during which the data contained in the photomicrographs are converted to the frequency area by means of a laser diffractometer and presented as spectral estimates for subsequent machine analysis; and 3) the second level of statistical processing, in which convolutions and functionals are generated providing a complete description of the images analyzed in the computer. The approach suggested yields the following information from fatigue fracture surface images: the spacing of fatigue furrows and their spectral composition in the observed interval; the rate of development of the major crack taking the contribution of each measured dimension into account; the path of the major crack; and the fracture focus. References 7: 6 Russian, 1 Western (in Russian translation).

UDC 539.4

The Strength of Tantalum Under Shock-Wave Test Conditions

18420046g Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 24 Nov 86) pp 114-117

[Article by V. K. Golubev, A. I. Korshunov, S. A. Novikov, Yu. S. Sobolev and N. A. Yukina, Moscow]

[Abstract] The strength of tantalum was studied in a specific initial state and under specific shock-wave test conditions. Studies were performed on a plate of high-purity tantalum 10 mm thick with a mean microhardness of 2.11 GPa. Shock-wave loading was achieved by the impact of a 4 mm thick aluminum plate accelerated by detonating a layer of plastic explosive. At normal temperature, the tests always produced ductile fracture, yielding pores or cavities transverse to the direction of impact. At -196°C, a more brittle form of fracture was also seen, related to the appearance of small cracks during the initial stage of failure. The range of shock-wave loads corresponding to various stages of fracture are listed. References 5: 2 Russian, 3 Western.

UDC 620.169.2

Some Possibilities for Accelerating Test-Stand Testing With Random Loading

18420046h Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 28 May 86) pp 117-119

[Article by A. A. Rakitskiy, M. I. Gorbatsevich and V. I. Sholomitskiy, Institute of Machine Reliability and Durability Problems, Belorussian Academy of Sciences]

[Abstract] Specimens were tested in tension and compression on a computer-controlled test stand, with the loading conditions based on a recording of the stresses on truck running gear parts corresponding to a 1.5 km stretch of gravel road. To accelerate the testing process, the road recordings were centered, setting the expected value approximately equal to zero, and amplified to the absolute maximum load corresponding to the yield point of the material. Other irregular loading conditions were generated to determine the possibility of further acceleration of testing: type two loading was produced from the first type by filtering out smaller stresses constituting about 12 percent of the maximum stress spectrum. In loading type three the repetition frequency of loading extremes was increased to 15 Hz. In loading type four, the maxima and minima of the narrow-band process were mixed in the computer. In type five, the narrow-band process was reduced to one with a constant, zero, asymmetry factor by analyzing half cycles based on the experimentally determined fatigue resistance characteristics of the material. It was found that increasing the repetition frequency of extremes to over 10 Hz significantly increased test duration. Arbitrary mixing of maxima and minima cannot be recommended. Elimination of amplitudes below 50 to 70 percent of the initial endurance limit can be used to accelerate testing. References 5: all Russian.

UDC 539.4

Viscoelastic Properties of Oriented Polymer Products Under Dynamic Loading

18420046i Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 88 (manuscript received 26 Jun 85) pp 120-121

[Article by A. M. Stalevich and A. G. Giniyatullin]

[Abstract] The purpose of this work was to provide a mathematical description of the stress-strain state of oriented polymer products such as tapes and cords under dynamic loading with subsequent free or forced oscillation. The equation defining nonlinear viscoelasticity was composed for monotonic deformation modes taking into account the activating effect of the load, using a relaxation kernel without a singularity. The reliability of the method was tested by solution of the inverse problem, computation of the load required to produce a measured deformation process. References 7: all Russian.

UDC 669.017:548.4:548.313

Possibility of Antiphase Band Flat Defects in Intermetallides

18420054b Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 13 Apr 87) pp 64-67

[Article by M. D. Starostenkov and N. V. Gorlov, Altay Polytechnical Institute]

[Abstract] An attempt is made to analyze the variation in energy of antiphase boundaries in 111 in curly braces-type planes in alloys with superstructure $L1_2$ as a function of height h and the disorientation angle between the shear vectors of the antiphase boundaries forming a complex. A model crystallite block in equilibrium for all possible atomic displacements was calculated by seeking the minimum internal energy of a system containing antiphase boundaries. Antiphase bands, like antiphase boundary tubes, are defects unstable in translational shear. Stabilization is achieved by additional shear of 111 in curly braces planes in the direction parallel to the plane of the defect. The significant reduction in energy of a complex of antiphase boundaries and complex deformation fields of the crystalline lattice of an alloy near an antiphase band contributes to the processes of deformation hardening. References 19: 13 Russian, 6 Western (2 in Russian translation).

UDC 621.357.7;669.539.43

Multilayer Composite Nickel-Boron-Chromium Coatings

18420049a Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 27 Nov 87) pp 9-17

[Article by V. I. Pokhmurskiy and R. S. Mardarevich, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] Due to the complexity of the joint precipitation of boron and chromium particles, the authors suggest the following plan for formation of a three-component composite coating: successive precipitation of the composite nickel-boron layer and the chromium precipitate with subsequent diffusion annealing in an inert atmosphere or a vacuum. In order to optimize the precipitation conditions of the two-layer coating, the influence of suspension concentration on composition and structure of the coatings must be studied, electrolysis conditions which maximize the inclusion of boron particles in the coating determined, and the electrolyte and chromium precipitation conditions selected. It was found that as the suspension concentration is increased to 50 kg/m^3, the content of particles in the coating increases to 4-5 mass percent, though further increases result in saturation. The coatings were heat treated by annealing in an inert medium at 850-1000°C for 1-4 hours. A fine-grained structure of one- or two-layer coatings heat treated at 850°C did not decrease the endurance of specimens at room temperature, while increasing endurance at 500°C by 40-60 percent. Large-grained single-layer nickel-boron coatings did not increase the high temperature endurance of specimens due to their greater brittleness. Two-layer coatings of the same structure did increase endurance by 40 percent. The advantage of two-layer coatings is still more clearly seen at 700°C. References 24: 23 Russian, 1 East European (in Russian translation).

UDC 620.197.3

Mechanism of Inhibiting Effect of Pyridine Derivatives on Acid Corrosion and Electrolytic Hydrogenation of Steel

18420049b Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 1 Apr 86) pp 45-47

[Article by V. V. Ekilik and A. I. Makhanko, Scientific Research Institute of Physical and Organic Chemistry, Rostov State University imeni M. A. Suslov]

[Abstract] A study was made to determine the relationship between the activation and blocking factors in the inhibition of acid corrosion and electrolytic hydrogenation of steel by certain organometallic pyridine and pyridinium derivatives. The inhibitors studied significantly decrease differential capacitance, increase polarization resistance, inhibit corrosion processes and reduce the speed of the electrode reactions involved. The blocking effect is found to predominate, particularly for high concentrations of inhibitors. The blocking nature of the action of these inhibitors indicates they should be quite universal, suppressing hydrogenation of steel. References 9: all Russian.

UDC 669.187.526:669.245.693:539.4.014.13

Study of Residual Stresses in Ceramic Coatings

18420066d Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 3, Jul-Sep 88 (manuscript received 25 Jul 86) pp 45-47, 67

[Article by L. Yu. Novosad, O. V. Tsygulev, B. A. Movchan, N. I. Grechanyuk and V. V. Grabin, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] An experimental and mathematical estimate is presented of the residual stresses in zirconium dioxide-based ceramic coatings and means for their effective reduction are sought. Studies were performed on type EI868 nickel alloy and niobium substrates such as those used for the manufacture of gas turbine blades, with a zirconium dioxide ceramic coating stabilized with yttrium oxide. The porosity and phase composition of the ceramic layer were varied. Bending of specimens was measured directly after precipitation of the protective layer and cooling, then after annealing at 1050°C for two hours in a vacuum. It was found that by increasing the porosity of the ceramic layer, the growth rate of residual stresses could be significantly decreased. However, increasing porosity to over 15-17 percent decreases the protective properties of the ceramic layer due to increasing gas permeability. Therefore, the effect of second-phase particles on residual stress growth rate with increasing coating thickness was studied. The second phase consisted of niobium and cerium sulfide particles at up to 3 percent. The porosity of the modified condensates was 15-17 percent. A functional relationship was discovered between porosity, the proportionality coefficient of residual stress growth rate and protective coating thickness. Variation of porosity and phase composition can be used to permit a significant increase in protective coatings, thus increasing their effectiveness. References 3: all Russian.

UDC 669.187.526:620.169.1:621.793.14.001.5

Corrosion Strength of Two-Layer Co-Cr-Al-Y/ZrO_2 Condensation Coatings in Gas Turbine Fuel Ash

18420066e Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 3, Jul-Sep 88 (manuscript received 16 Sep 87) pp 52-56

[Article by V. A. Movchan, Yu. D. Sklyarov, A. I. Rybnikov, A. Ye. Levin, I. S. Malashenko and S. V. Domoroslov, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the corrosion strength of a two

layer Co-Cr-Al-Y/ZrO_2-8 percent Y_2O_3 coating and a single-layer Co-Cr-Al-Y metallic coating on cylindrical specimens, 7 mm in diameter and 50 mm long, of EP99 alloy. The chemical composition in both cases was, in percent, 26-27 Cr, 7-8 Al. Specimens with metal coatings were heat treated and hardened. The ceramic coating was applied by evaporation, yielding a microhardness of 4200-6500 MPa corresponding roughly to 10-12 percent microporosity. Tests were performed in contact with synthetic gas turbine fuel ash containing, in percent: Na_2SO_4 66.2, Fe_2O_3 20.4, V_2O_5 1.8, NiO 8.3, CaO 3.3. The corrosion resistance of the coatings was evaluated by metallographic and gravimetric methods. The results indicated significantly greater corrosion strength of the two-layer coating than the single-layer metal coating when tested at 750-800°C in gas-turbine fuel ash. The greater strength of the metal-ceramic coating results from the fact that the outer ceramic layer does not interact with the salts contained in the ash and limits the contact of the corrosive substances with the heat-resistant metal coating. References 10: 4 Russian, 6 Western.

Composite-Materials Association's Research, Introduction Programs

18420136 Moscow IZVESTIYA in Russian 31 Jan 89 p 2

[Article by S. Leskov, interviewer.]

[Extract] A program of cooperation between the Executive Committee of the Moscow City Soviet (Mossovet) and the scientific production association "Kompozit" (composite materials) has been outlined for the purpose of solving first-priority problems of the city's economic development in 1989-1991. Similar programs with the USSR Ministry of Health and the Ministry of Installation and Specialized Construction Work have also been approved. Doctor of Technical Sciences Stanislav Petrovich Polovnikov, general director of the "Kompozit" association, told how space technology and materials science will be used in the economy.

"With the transfer of the industry to the system of economic accountability, enterprises cannot make do with money from the state budget alone; they need funds and currency of their own [said S.P. Polovnikov]. We were therefore quite ready to respond to academician V.S. Avduyevskiy's proposal that we establish contact with Mossovet's Main Administration for Science and Technology. V.T. Saykin, chairman of Mossovet, supported a plan that was outlined. The Soviet will provide assistance in concluding mutually advantageous contracts and allocate additional space."

"The plan of joint work contains several dozen extensive items, and several million rubles must be put to work in 1989. Isn't this too ambitious an undertaking?"

"Our plans have been checked out and are quite realistic. Take health care, for example. Tendons, ligaments, artificial blood vessels and tympanic membranes can be produced on the basis of a special carbon material that has been developed in the USSR. This material is two to three times superior to lavsan from the standpoint of its principal medical parameters, such as thromboresistance.

"Our association has organized cooperation with the Central Institute of Traumatology and Orthopedics (TsITO) for the purpose of developing new materials for endoprosthetics and materials on a qualitatively new level for medical instruments. Broad employment of composite materials in this direction will shorten treatment time by two-thirds to four-fifths and make it possible to perform unique operations and restore the working fitness of people in cases where this was recently considered difficult or even impossible. To keep you from thinking that this is a thing of the remote future, I shall mention that an operation employing an implant made of a special high-strength steel developed for rocket engines was performed successfully at TsITO not long ago. Production of 'spare parts' for human beings begins this year."

"Is there a real possibility for use in the economy of materials, developed in space laboratories, which differ fundamentally from terrestrial ones with respect to physical characteristics?"

"Of all the various directions of space materials science, the one which I consider the most realistic in the years immediately ahead is starting production in orbit of medicines and biological preparations. A more difficult task is to master production of components for microelectronics which requires large power-generating capacities and almost total absence of any accelerations. Taking these circumstances into account, I shall name a figure which is quite realistic, in my opinion—bringing space production up to 3 to 5 billion rubles' worth a year by 1995."

"Extensive data on composite materials which is at the disposal of your enterprise and related ones needs to be systematized. How is a potential partner who wishes to cooperate with you to find out about these new materials?

"In accordance with instructions from superior organizations, a computer center has been created with a wealth of data in a bank. Information on 300,000 different characteristics of materials is stored there. Mathematical models of processes which develop in materials under different loads are being developed on the basis of this data bank. We are ready to familiarize all of our colleagues with it. Talks have already begun with a number of enterprises in regard to creating a nationwide information network."

UDC 539.4:678.067

Destruction of Polymer Composites by Laser Radiation

18420094a Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 88 (manuscript received 28 Jul 87) pp 22-28

[Article by S. G. Bychkov, S. M. Mashakova, Ye. D. Glebov, G. V. Kuznetsov and Ye. A. Barbashev, Alma-Ata]

[Abstract] The following widely used composites were studied: organoplastic with epoxy phenol binder and glass-reinforced plastic based on polyimide and organosilicon binders. The materials were exposed to continuous radiation by a CO_2 laser and a IAG laser at 17, 22 and 27 W. The dynamics of the temperatures on the front and back surfaces of the specimens and of the color temperature of the irradiated zone, mass loss kinetics, crater formation and ignition, changes in reflectivity and the composition of condensed destruction products were studied. The mean linear speed of destruction was measured with the radiation focused to a power density of $1.9 \cdot 10^4$ and $3.3 \cdot 10^4$ W/cm^2 respectively. Although the mechanism of laser destruction of the composites is determined by the thermal stability of both components,

the binder is most important due to its ability to form a coke ablation layer with high specific carbon content. The maximum effect is achieved only by optimizing the relationship between the energy receiving area and the degree of shielding of deeper layers of the material by the condensed products. References 10: 9 Russian, 1 Western (in Russian translation).

UDC 669.2/.8:620.22-419.8

Multilayer Hard-Alloy Composite Materials

18420118b Moscow TSVETNYYE METALLY in Russian No 11, Nov 88 pp 80-84

[Article by I. Yu. Konyashin and A. I. Anikeyev]

[Abstract] The appearance of hard alloy tools with wear-resistant coatings, forming a unique type of composite material, has been a revolutionary factor in the intensification of metal working processes, comparable in its impact to the development of titanium-containing hard-alloy materials in the 1930's. Organizing the widespread manufacture and use of hard alloys with wear-resistant coatings can solve many important economic problems, increasing the life of tools, improving their productivity, increasing the quality of machined surfaces, decreasing costs, reducing the variety of different tools required and decreasing cutting forces required to perform work. The history of development of such tools in the West is briefly described. A new technology for the manufacture of multilayer hard-alloy composites by combining chemical and physical precipitation methods has been developed in the USSR. These tool materials, while retaining good wear resistance, also have strength characteristics significantly superior to materials produced by chemical vapor-gas phase precipitation. The volume of the production of these materials is to be increased by a factor of 5 during the 12th Five Year Plan, which is expected to achieve an economic effect of over 100 million rubles. References 27: 16 Russian, 11 Western.

UDC 539.377:678.067

Thermal Deformation of Composite Reinforced With Hybrid Woven Strips

18420037a Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 9 Oct 87) pp 392-401

[Article by E. Z. Plume and V. M. Ponomarev, Polymer Mechanics Institute, Latvian Academy of Sciences, Riga]

[Abstract] The elasticity and linear thermal expansion coefficients of woven composites are determined using a stratified model. The initial characteristics are the elasticity and linear thermal expansion coefficient of the binder and the fibers. In contrast to other simple methods, the use of the theory of layered plates allows more precise consideration of the true deformation conditions of the entire specimen, which is of significance for determination of the elasticity characteristics and linear thermal expansion coefficient of a layer with regular curved fibers. The structure of the composite is studied on the example of a two-layer material, with one layer reinforced with straight fibers, the other layer reinforced with fibers in the opposite direction with regular curvature, with material broken into these arbitrary layers such that the reinforcement percentage in both layers is the same, equal to the total reinforcement coefficient. Five batches of composite specimens were studied experimentally. The variation in relative content of the layer types used allows the thermal expansion of a composite in the longitudinal direction of the reinforcing fibers to be varied significantly, while the modulus of elasticity changes little. References 23: 15 Russian, 8 Western.

UDC 539.4:678.067

Layer Separation of Composites Under Combined Loading

18420037b Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 9 Nov 87) pp 410-418

[Article by V. V. Bolotin, Machine Science Institute imeni A. A. Blagonravov, USSR Academy of Sciences, Moscow]

[Abstract] The problem of the short-term and fatigue fracture of multilayer and layered fiber composites under combined loading, particularly the combination of layer separation and shear between layers, is studied within the framework of analytical fracture mechanics. It is shown that in order to achieve agreement between the analytic results and experimental data, generalized coordinates must be introduced which independently yield the position of the separation and shear fronts. The method is illustrated for problems concerning the resistance of fine separating layers located at the surface of compressed multilayer composite elements. The behavior of a flat crack in a macroscopically orthotropic elastic composite is analyzed. The approach used is illustrated by the problem of layer-separation resistance in a compressed element consisting of a multilayer composite. The approach is extended to the problem of the growth of fatigue cracks under combined loading. References 12: 7 Russian, 5 Western.

UDC 539.3:678.067

Composites Reinforced on the Diagonals of a Cube. 1. Shear and Compression Resistance

18420037c Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 15 Jul 87) pp 419-425

[Article by I. G. Zhigun and V. A. Polyakov, Polymer Mechanics Institute, Latvian Academy of Sciences, Riga]

[Abstract] Composites reinforced on the diagonals of a cube are promising from the standpoint of increasing the shear strength in the major planes of elastic symmetry

and at 45° to them. Such composites have a higher content of reinforcing fibers than 3D-reinforced composites, and therefore have greater rigidity and strength. Equations are derived in this article which describe the strength and modulus of elasticity in the directions of the major axes of elastic symmetry in such composites. The equations indicate that there is no multidirectional reinforcing scheme which leads to cubic symmetry of elastic properties and produces elasticity moduli on the major axes of elastic symmetry greater than in a material reinforced in three orthogonal directions. Clear superiority of 4D-reinforced materials over 3D materials is seen only in shear modulus. The 4D materials are inferior to 3D materials in other physical characteristics. Variation of the fiber slope angle, parallel to the diagonals of a regular parallelipiped, can increase modulus of elasticity and decrease shear modulus, yielding characteristics approaching those of a unidirectional material. References 7: all Russian.

UDC 539.37.001:539.219:678.029.5

Anomalous Behavior of Viscoelastic Properties of Certain Polymer Composites

18420037d Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 10 Aug 87) pp 442-448

[Article by S. K. Kanayan, A. Ya. Goldman and L. T. Kudryavtseva, Plastpolimer Scientific-Production Association, Leningrad]

[Abstract] There are polymer composites in which the elasticity modulus is less than the elasticity modulus of the most pliant component. This is called an anomalous effect. This article analyzes effects related to anomalous decreases in dynamic elasticity modulus of mixtures based on practically incompatible polymers, as well as impact-resistant systems. Experimental data for two types of polymer mixtures are used to suggest theoretical models to describe the anomalous behavior of the dynamic elasticity modulus as a function of temperature. The effect of decreased elasticity modulus in the vitreous state is found to be rather common and is observed in many polymer systems. Introduction of a weakened transition layer to the computation model yields a satisfactory description of the dynamic mechanical characteristics of such composites and allows evaluation of the bonds at the interface between the matrix and reinforcing inclusions which are retained during partial layer separation. References 11: all Russian.

UDC 539.4:539.219.2:678.067

Strength and Crack Resistance of Fiber Composite Materials With Polymer Matrix Under Long-Term Static Loading

18420037e Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 19 Sep 87) pp 457-461

[Article by G. P. Zaytsev and G. V. Arkhipov; Moscow Aviation Technological Institute imeni K. E. Tsiolkovskiy; Krasnoyarsk Institute of Nonferrous Metals imeni M. I. Kalinin]

[Abstract] Crack resistance characteristics were studied under long-term static tensile loading in plastic specimens reinforced with glass, organic materials and carbon fibers with a central notch. The experimental data on crack growth over time were processed statistically. It is found that glass- and organic fiber-reinforced plastics are type A materials, in which cracks propagate in the direction of the initial notch and failure of the specimen occurs by separation into two parts along the crack, while carbon-reinforced plastic is a type C material, in which the crack length does not increase during the testing process, failure occurring suddenly due to accumulation of defects which are difficult to observe. The logarithm of crack growth rate in GRP can be described by the linear relationship of the logarithm of the difference between initial and failure stress intensity coefficient and the logarithm of the initial stress intensity coefficient in organic-reinforced plastic to the logarithms of the initial and current stress intensity coefficients. For carbon-reinforced plastics, the crack opening curves are similar up to the third stage of failure for various values of initial stress intensity factor. The durability of notched specimens of all three types of materials studied is described by a phenomenological function of the same exponential type, the parameters of which depend on the material type. References 3: all Russian.

UDC 669.721.5+669.781:620.171.32:539.434

Influence of Temperature on Structure and Mechanical Properties of Magnesium-Boron Fiber Composite Materials

18420037f Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 6 Oct 87) pp 468-471

[Article by G. G. Maksimovich, A. V. Filipovskiy, V. I. Mikheyev, A. I. Gordiyenko, I. V. Tarasenko and Ye. N. Vinogradova; Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov; Institute of Materials Science Problems, Ukrainian Academy of Sciences, Kiev]

[Abstract] A study is presented of the influence of temperature on the short-term and long-term strength and of the influence of thermal cycling on the structure of a composite material based on magnesium reinforced with boron fibers, produced by high-temperature compression of packets consisting of unidirectionally reinforced monolayers. Thermal cycling tests were performed in an atmosphere of argon at temperatures between 150 and -196°C. As the test temperature increased, the strengthening effect of the reinforcement increased as well. The plasticity of the composite materials remains practically constant at all test temperatures. The boron fibers always failed by brittle fracture, the matrix always failed by ductile fracture. Reinforcing magnesium alloys with boron fibers can create structural composites with good specific strength capable of operating at temperatures of up to 300°C. Thermal cycling

causes significant structural damage as thermal stresses are relieved by fracturing of the fibers and composites, thus reducing the strength properties of the material. References 9: all Russian.

UDC 539.434:678.067

Fatigue of Epoxy Composites With Dispersed Filler at High Loading Frequencies

18420037g Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 16 Nov 87) pp 472-475

[Article by A. N. Bobryshev, Ye. N. Kapustyanskiy and V. I. Solomatov, Penza Construction Engineering Institute; Penza Technical School-Plant (affiliated with Penza Polytechnical Institute); Moscow Railroad Transport Engineers Institute]

[Abstract] A study is made of the problem of optimizing the filling of composites on the basis of fatigue testing results. Epoxy composites based on ED-20 resin and filled with ground quartz were studied. The volumetric content of filler was varied between 0 and 71 percent. Fatigue test specimens were made by casting. Ultrasonic fatigue testing was performed in a magnetostriction loading machine. Hysteresis resulted in vibration heating of the composite, decreasing its fatigue strength during the course of the testing. Optimization of filling is performed to minimize the internal friction in the composites. An equation is presented for computing the number of loading cycles to failure which can be used to optimize the filling. At lower loading frequencies, the composite can relax during the comparatively long intervals between loading cycles, which influences the process of failure and which means that the equation may not be applicable under different fatigue loading conditions. References 12: all Russian.

UDC 678.02:620.168:534.6

Saturation of Fiber Fillers With Polymer Binders. 2. Influence of Saturation Conditions on Saturated Filler Strength

18420037h Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 22 Dec 87) pp 490-496

[Article by A. Ye. Kolosov, I. A. Repelis, V. G. Khozin and V. V. Klyavlin; Kiev Polytechnical Institute imeni the 50th Anniversary of the Great October Socialist Revolution; Kazan Construction Engineering Institute; Polymer Mechanics Institute, Latvian Academy of Sciences, Riga]

[Abstract] During saturation of a unidirectional fiber structure, there is great anisotropy of capillary permeability of the binder along and across the fibers. The authors study the saturation process on the assumption that the rate of movement of the filler is determined by its speed of saturation. The capillary rise of a binder along a fiber was used to model the actual conditions of saturation of reinforcing fibers by polymer binders. It is found that the rate of longitudinal saturation varies with the volumetric density of the fiber material. Beginning at a certain value of tensile force on the filler, the rate of longitudinal saturation decreases with increasing tension, apparently due to the difficulty of the movement of air inclusions from the filler as its structure is compacted by the force. A method is suggested for determining the optimal time and tensile force for saturation of filler, assuring the maximum speed of longitudinal and transverse saturation and thus the maximum bonding strength between matrix and filler. The method, based on light transmission and acoustic emission during saturation of transparent oriented fiber fillers with polymer binder, is an effective method for investigation and monitoring of the process. Ultrasonic intensification of the process, facilitating movement of air through the pores of the composite and penetration of the binder between fibers, can be used to intensify the process. References 20: all Russian.

UDC 678.02:538.6

Influence of Changes in Conformation Caused by Homogeneous, Constant Magnetic Field on Curing of Epoxy Resin

18420037i Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 5 Oct 87) pp 497-502

[Article by Yu. P. Rodin and Yu. M. Molchanov, Polymer Mechanics Institute, Latvian Academy of Sciences, Riga]

[Abstract] Thin-film IR spectroscopy was used to study the curing of epoxy resins in a magnetic field. Interaction of benzene rings with the magnetic field causes orientation of the diane groups and the entire epoxy resin molecule, leading to the formation of hydrogen bonds between molecules and facilitating breaking of the epoxy rings. The orientation order created in the resin by the magnetic field, by increasing the number of hydrogen bonds between oligomer molecules, leads to the formation of intermolecular C-O-C bonds. Without a curing agent present, a magnetic field of 20 kE results in opening of the epoxy rings in the oligomer to 10-20 percent. References 14: all Russian.

UDC 62.562+621.8-03:678.067

Metal Composite Flywheel With Fixed Maximum Angular Rotating Speed

18420037j Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 27 Nov 87) pp 519-525

[Article by G. G. Portnov and I. A. Kustova; Polymer Mechanics Institute, Latvian Academy of Sciences, Riga; All-Union Electrical Machine Building Scientific Research Institute, Leningrad]

[Abstract] The purpose of this work was to select materials and winding conditions and to study the power capacity of specific flywheel structures by analyzing their

stress states. It is shown that for a fixed angular rate of rotation, the power capacity of solid cylindrical metallic flywheels is less than the power capacity of hollow cylinders of the same external radius, wound of composites in a manner such that the specific elastic characteristics of the material change through the thickness of the cylinder, so as to eliminate radial stresses in the rotating cylinder. This is achieved by changing the angle of winding of the fibers as the thickness of the cylinder increases. Alternately, different reinforcing materials can be used through the thickness of the cylinder. For some materials there is an optimal ratio of the inside to outside radius of the cylinder, for which the moment of inertia of the metal-composite flywheel is maximal. References 5: all Russian.

UDC 624.073:678.067:539.53

Formation and Growth of Technological Defects in Pressed Composite Products

18420037k Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 29 May 87) pp 526-533

[Article by A. N. Vorontsov and G. Kh. Murzakhanov, Moscow Power Engineering Institute]

[Abstract] A study is made of the change in the stress-strain state in a prismatic specimen of a layered composite material as it is formed under compression in order to determine the probable zones where defects might form and the residual stress state, which influences the behavior of the defects in use. The stability and growth of elliptical and circular layer separation areas located far from the lateral surfaces of the prismatic product are determined. It is found that residual stresses significantly reduce the durability of products containing manufacturing defects of this type. References 9: 8 Russian, 1 Western.

UDC 539.411.5:678.01

Relationship of Dynamic-Mechanical Losses To Impact Toughness of Elastomer-Modified Polyvinyl Chloride

18420037l Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 24 Dec 87) pp 547-550

[Article by K. N. Smirnova, V. P. Lebedev, T. B. Zavarova and R. I. Petrova, Yakutsk State University]

[Abstract] In order to reveal the connection between impact toughness and mechanical losses, a comparison is made of the variation of parameters determining these characteristics with changes in the time of impact action. Impact fracture resistance is described by curves showing the variation in load and mechanical losses are described by the variation in mechanical loss angle tangent, both as functions of time. Studies were performed on polyvinyl chloride materials stabilized with lead salts and PVC composites with elastomer impact toughness modifiers, copolymers of methyl methacrylate, butadiene and styrene. It is found that the maximum loss angle tangent of the modifier occurs earlier than the active deformation absorption of energy by the composite, the level of elastomer energy dissipation being greater than the level of PVC energy dissipation. An increase in modifier content thus naturally increases the level of total relaxation energy dissipation in the composite, which decreases the forced elasticity limit and increases deformation and work of fracture. This energy absorption sequence explains the relationship of impact toughness with dynamic-mechanical losses in composites and shows the indirect nature of this connection. The intensive deformation energy absorption following intensive relaxation absorption yields the high level of impact toughness. References 9: 6 Russian, 3 Western.

UDC 539.411:678.067.5

Correlation Between Work of Fracture and Impact Toughness of Glass-Filled Thermoplastics

18420037m Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 8 Dec 87) pp 550-551

[Article by A. Ya. Malkin and M. A. Kutsenko, Plastmassy Scientific-Production Association, Moscow]

[Abstract] The relationship of impact toughness to other absolute strength property characteristics of thermoplastics is studied for a comparatively new class of structural polymer materials, the glass-filled thermoplastics. The work of fracture in uniaxial extension and impact toughness were measured in unnotched specimens of polyamide and a copolymer of trioxane with dioxalan containing 30 percent glass fiber and polycarbonate containing 10, 20 and 40 percent glass fiber. The correlation between work of fracture and impact toughness is found to be linear, regardless of type of polymer matrix and quantity of glass fiber introduced, meaning that impact toughness measurements can be replaced in principle by the more reliable and reproducible measurements of work of fracture in uniaxial extension of standard specimens. References 3: 2 Russian, 1 Western.

UDC 539.338.1:539.413:678.067

Influence of Stress Concentrator on Fatigue of Glass-Reinforced Plastic in Flexure

18420037n Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 17 Dec 87) pp 551-554

[Article by P. P. Oldyrev, Polymer Mechanics Institute, Latvian Academy of Sciences, Riga]

[Abstract] Results are presented from an experimental study of the influence of circular apertures on the fatigue of a glass-reinforced plastic in multicyclic pure flexure. The possibility of estimating this influence based on the results of testing of specimens under static loading is also studied. Tests were performed on glass-reinforced textolite using an epoxy-phenol binder, reinforced with glass fabric. The circular aperture stress concentrators were found to have a slight negative effect, not over 5 percent, on the material in static and cyclic flexure. The concentration coefficients were practically equal considering the peculiarities of fracture of

a layered plastic material with a stress concentrator in static bending. The virtual equality of stress concentration factors for static and cyclic flexure can significantly reduce the testing required to determine multicycle fatigue strength of such products with concentrators. A fatigue curve must be produced for smooth specimens, then the concentration factor is determined for specimens with concentrators in static flexure, and used to correct the endurance limits. References 7: all Russian.

UDC 629.7:620.171.34

Influence of Stiffening Rib Cross-Sectional Shape on Stress State of Envelope

18420037o Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 88 (manuscript received 28 Dec 87) pp 554-557

[Article by E. V. Ganov, V. D. Popov, O. A. Pivnenko and N. M. Ryndenkova; Leningrad Ship Building Institute; Ritm Scientific-Production Association, Leningrad]

[Abstract] Several cross sections of stiffening ribs in the area of contact with a shell were studied: right angle contact, circular curving contact, initial thickening of the rib as it approaches the surface, followed by a circular curve, and initial thinning of the rib, followed by a circular curve. The stresses in each element and deformations at the intersections were then determined by computation. It was found that rounding the stiffening ribs in the area of the connection significantly reduces stresses in areas where they are concentrated by a right angle connection. Stresses are least for ribs which increase gradually in cross section, then are rounded at the intersection with the shell. References 3: all Russian.

Steel Worker Urges New Approach to Workplace Safety

18420001 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 14 Aug 88 p 1

[Letter to the Editor by V. Stavtsev, CPSU member, brigade leader and member of the labor collective council of the Orel Steel Rolling Plant: "We Shouldn't Have To Pay For It With Our Health"]

[Text] My plant is 21 years old, making it 11 years younger than myself. However, you could say that the Orel Steel Rolling Plant is actually much older than that. But more about that later. First, I want to say that I really like my plant. It is in good standing with both the Ministry of Ferrous Metallurgy and with the citizens of Orel. After all, the plant is a leader in the industry, especially with regard to living conditions and cultural amenities. Our Palace of Culture is a true palace; even Muscovites would envy its facilities. We have many excellent cafeterias which are as nice as good restaurants. The food is very good, and the prices are reasonable: lunch costs no more than 60 kopecks.

There's more. We have a good dispensary, and the shops have food stores which are always stocked with milk, poultry and butter, and sometimes with meat. Everything is produced by our own subsidiary farms. And we can't complain about our wages. The working conditions are not as severe as in steel-making or hot-rolling plants. Yet, despite all these benefits, the plant is understaffed by about 700 workers. People aren't coming to work here. What's worse, people are leaving.

This can be attributed partly to the housing problem. But the main reason is the working conditions.

In general, our work is not so easy. Let me say again that I really like this plant. Ten years ago, I arrived here as a youngster. All I did the first few weeks was follow an experienced worker around and watch what he did. The equipment seemed fantastic. I was amazed by the machines and production lines, which were designed down to the last detail. After about 3 months I was completely acclimatized, and was playfully loading empty spools on the machine and removing the heavy filled ones (I am a cordmaker producing steel cord for motor-vehicle tires).

After several years I began to understand that this job wasn't so easy. It was at a time when we were starting to use the brigade contract method, which had been introduced by our shop chief (now plant director) Alekseyev. Our brigade didn't operate smoothly at first, but it gradually coalesced. Although the work norms call for 22 workers in our brigade, it never has had more than 13-15. Since the brigade is paid for the full 22 people, each of us earns nearly as much as a ministry employee. Some people might say that the norms are incorrect. No. I would answer, the norms are all right. It's just that we have developed into a very good brigade. At one time there were two women working in the brigade. They are still at the plant, although not in this brigade any longer. They said it was difficult to load the 10-kilogram spools on the machines and even harder to remove the heavy full spools all day (this amounts to many hundreds of kilograms per shift), the return home to their housework and shopping duties.

It was then that I started to understand that our plant wasn't so advanced after all, despite our leading place in the industry and our beautiful lines of machinery.

All you should have to do is feed in the ends of the wires, press a button and let the machines do all the rest. But the wire must be inserted by hand, and the finished product must be removed by hand. No small-scale mechanization or auxiliary equipment has been provided, although it seems to me that it would be easier to design than the automatic machines which strand the cable.

The problem isn't just that you have to handle tons of metal each sift. Sooner or later, someone inevitably drops one of the heavy filed spools on his foot. It's no surprise that over half of all injuries are broken bones, while 20 percent are contusions.

About 2 years ago, there was an incident in which a person was literally cut in half instantaneously when he was caught in a loop of wire. He had been standing inside the loop and gone ahead and started the machine. This extraordinary event caused a big uproar, and measures were taken to prevent this from ever happening again. In particular, photocells were installed in this section to turn off the machine whenever a person entered the danger zone.

What was the workers' response to this? They invented ways to circumvent the photocells. They didn't want to lose time by stopping the machine. After all, none of us believed that it could actually happen to us. This is a characteristic trait of human beings. The more experienced and mature a person is, the stronger is this belief.

Do you think that most production injuries happen to inexperienced workers? Not at all: according to data collected by V. Ressin, assistant chief engineer for safety, the greatest number of accidents occur with experienced workers, even those with 30 years experience. I don't know whether this is the result of long-term fatigue, overconfidence (which probably also increased with experience) or inattention. I don't know if the last of these is linked with age or not. It is for scholars to untangle these closely interrelated factors. What I would like to say is that we need a fundamentally new approach to safety.

In those places where there is even the least threat to human health, the entire manufacturing process must be redesigned to eliminate humans from the process area. Robots, not people, should be lugging heavy steel products around. It should be physically impossible for

people to stick their hands into a machine or enter a danger zone where there is even a once-in-a-century chance of an accident. Ideally, I would like to see a automated, workerless technology. In our plant, and in the metallurgical industry in general, this is still in the very distant future, but we will have to achieve it someday. I just can't reconcile myself with the fact that our plant, which is supposedly an industry leader, still utilizes 22.4 percent manual labor.

When I said earlier that my plant is old, I had this sobering figure in mind. It turns out that the plant was old even before it was built, because it was designed that way. We have been using our present equipment for 10 years. It is not only worn out, but obsolete as well. We urgently need new, and preferable domestically manufactured, equipment.

There are about 500 people working under hazardous conditions here. They work in the heat treatment and pickling shops, where the levels of sulfuric and hydrochloric acid fumes and carbon monoxide are one and a half times higher than the maximum permissible. They also work in the electrode shop, where the level of manganese dust is twice the norm. And they work in the cable shop and the steel wire-fastener shop, where the noise is higher than permissible.

All of this was designed into the plant. Just take a look at our first shop, which began producing wire in 1967. It is crowded and low-ceilinged; there are sharp temperature changes and drafts. Today, it is more or less light enough, because we made our own skylights in the roof; the original lighting was terrible. And in my shop, which is relatively new, we are forever making our own improvements.

Now I would like to say a word about the so-called maximum permissible coefficients, the MPC's. It seems to me that this hazard indicator is extremely arbitrary. It shouldn't be used at all. These sections should be sealed off from workers. This isn't too difficult a task for modern engineering.

I'm not at all convinced that medical scientists know the decibel threshold at which noise becomes excessive and harmful, or how many years a person can withstand all the din and racket without any consequences. Even if I get used to it and don't really hear it any longer, that doesn't mean that in 2 or 3 years I might not get hypertension or ischemia, which are the main causes of death and disability among working-age people. They say that noise is difficult to eliminate from production operations. However, people can be isolated from it in sound-proof rooms. This is being done at our plant, but the effort is far too modest.

It is obviously no accident that acute respiratory diseases, angina and pneumonia are the most common illnesses at our plant. I believe that this is directly related to drafts, temperature changes and respiratory damage caused by acid fumes. It seems to me that these factors basically could be eliminated, and since this matter has not been resolved, it must be given serious attention. After all, the people who create material wealth should not have to pay for it with their health. I hope that my thoughts on working conditions will be heeded at the USSR Ministries of Ferrous Metallurgy and Health, the AUCCTU and design bureaus.

(Signed) V. Stavtsev

Editors' Note:

This letter which we are publishing today is not the only one of its kind. This letter is alarming. It shows that in the rush to fulfill the plan and to live up to the slogans "fulfill and overfulfill," we have forgotten about the true goal of all material production. If production exists to meet the needs of human beings, then it must ensure the main requirement: health. After all, as the saying goes, you can't buy health in a drug store.

V. Stavtsev is calling for a fundamental change in attitude toward the conditions under which human being work. The editors fully support this point of view. We hope that our readers will continue the discussion.

Steel in Year 2000

18420067 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian No 237, 15 Oct 88 p 4

[Article by V. Andriyanov, N. Goncharov and S. Sadoshenko, Special Correspondents. Passages in boldface as published]

[Text] **How much metal do we need? Many years ago, we achieved first place in the world in the production of steel, and were proud of it, truly with good reason. Today, we still manufacture more of all metals, but there are still shortages. What should we do? Make more millions of tons? Or maybe fewer millions, but better quality?**

The answer to this question is not as simple as it might seem. Selecting a strategy for the development of ferrous metallurgy is essentially a problem of selecting the development of all branches of heavy industry. Concepts are now being developed for the economic and social development of the USSR in the period up to the year 2005. These concepts will reflect the basic ideas of the program which has been approved to decrease the metal content of national income.

A discussion was recently held at the invitation of the editors in Dnepropetrovsk, one of the centers of ferrous metallurgy, on the subject "Steel In the Year 2000." The discussion involved: Deputy Chairman of the USSR State Committee for Material and Technical Supply, S. Anisimov; Deputy Chief of the Consolidated Department of the Metallurgical Complex of the USSR State Planning Committee, A. Kogadeyev; Academician, Director of the Metallurgy Institute, USSR Academy of Sciences, N.

Lyakishev; Academician, Chairman of the Dnepr Scientific Center, Ukrainian Academy of Sciences, V. Pilipenko; First Deputy Minister of USSR Ferrous Metallurgy, General Director of Yuzhmetallurgprom State Production Association, S. Pliskanovskiy; Collegium Member, Chief of the USSR Ministry of Ferrous Metallurgy's Technical Administration, V. Antipin; and leaders of various enterprises, institutes, ministries, and party workers.

Where Is The Sign Post?

A business-like, pointed discussion began immediately. No apathy here—with very rare exceptions. We felt that this discussion was long overdue, that its participants would not be still until their opponents had heard their thoughts and concrete suggestions.

N. Lyakishev: There is probably nobody who can predict accurately how ferrous metallurgy will develop up to the year 2000 and beyond. But the future is always based on the past, which means we can make some predictions.

Not only in our country, but also abroad, people are asking: Where is ferrous metallurgy in the USSR headed? We have already surpassed the USA, where 150 million tons of steel are produced each year, but we can't stop here—that's the most important thing.

For many years we followed an extensive path of development. By opening new facilities, we added 50-60 percent, by intensification of old facilities—the other 40-50 percent. The result has put ferrous metallurgy in a very difficult position.

Now 95 percent of the structural materials in our country are made of steel. In other countries, where ferrous metallurgy developed intensively, steel represents only 85 percent of the structural materials. According to the specialists, even in the years 2000-2010 the basic structural material will continue to be steel (at the 90 percent level), as opposed to just 75-80 percent in the USA. Aluminum, polymers and ceramic materials, composites, all of which can replace steel, have not yet become popular here.

Now about metal quality. Obsolete technology, the open-hearth process, ingot pouring—all of this harms quality.

A. Kogadeyev: Open-hearth facilities produce more than half of our steel.

N. Lyakishev: And that's how it will be until we get away from the extensive path of development! I have suggested more than once that we should immediately stop increasing the volume of metal produced, and in the next five-year plan decrease it significantly. The money now spent to increase the output of steel should be directed toward improving its quality. Japan and the USA are continuing to make the same sort of capital investments in metallurgy as before, but they are investing in improved quality, while they decrease the quantity of metal produced.

S. Pliskanovskiy: I believe that when we look at the quality characteristics of the metal we have to consider who needs the quality. We have the capacity, but there are few orders from consumers for hardened low-alloy metal. Remember the example that hit all the papers. At Nizhnyy Tagil they opened a wide-strip beam shop. For two years they got no orders. Only then did their consumer make some changes, and suddenly there was a shortage of those beams.

At one time we started making metals with different guaranteed properties. We made them, but the orders were less and less. What happened? We studied the question together with the Ukrainian Academy of Sciences. It turned out, in order to use the metal, for example, in the Ministry of Installation and Special Construction Work, all their technical documentation had to be changed. So it turns out that instead of changing the paperwork we just make more metal, at tremendous cost in material and personnel.

N. Lyakishev: Yes, unfortunately, there is now a clear inclination of the consumer to want metals at lower prices, with lower quality. For example, the Ministry of Tractor and Agricultural Machine Building refuses to accept high quality metal from the Oskol Combine. But we can't figure out that type of consumer. Many machine building plants use this metal successfully and pay a higher price for it, deriving an unquestionable advantage from its reliability. Of course, in many cases ordinary metal can and should be used by improving its properties. But this isn't the main direction of development of metallurgy. Our final goal is to improve the quality of our metal. Sooner or later, the consumer will demand quality. If we can't raise the quality level of the metal up to the mark, we will find ourselves in a difficult position: they'll stop buying our metal.

S. Pliskanovskiy: In our plants, the production of open-hearth steel will decrease from year to year. By 1990 we plan to make 40 percent oxygen-converter steel, by 2005—about 90 percent. We are already making steel without increasing our consumption of cast iron, iron ore and coke. Then we'll start decreasing the number of blast furnaces. But their capacity per unit will increase, their equipment will be improved.

G. Kulagin, chief engineer, Dnepropetrovsk Metallurgical Plant imeni G. I. Petrovskiy: How can we decrease ferrous metal production? Quite simply. Here is an obvious example. At our plant we use a barbaric method to make metal—in ingots. People who have worked in this section for 8 or 10 years deserve a medal. It should be replaced by continuous casting. This not only will permit one to mechanize labor, but will also decrease the production of steel by 15 percent without decreasing the

yield of rolled products. At our plant, this would mean 300,000 tons less steel than now. This decrease in steel would mean 250,000 tons less pig iron. And so forth. Here is a concrete means to reduce the production of metal.

N. Lyakishev: But when does the USSR State Planning Committee intend to call for decreasing the output of steel?

A. Kogadeyev: In the plans for development of the economy of the USSR, the production of steel is to be stabilized in the 13th five-year plan, then, starting in the year 2000, its output will be gradually decreased. The major efforts of metallurgists should be directed toward sharply improving the quality and usage properties of metal products. This will allow us to satisfy the demand of the economy for ferrous metals while decreasing the actual physical volume of their production.

N. Lyakishev: I was a little bit puzzled by the answer of the representative of the State Planning Committee to the pivotal problem of our discussion: Where is the development of Soviet metallurgy headed? Let me emphasize again: We must not delay decreasing the output of steel beyond the year 2000. If we don't start following the intensive path of development now, the situation in ferrous metallurgy may become catastrophic.

V. Filatov, chief engineer, Glavchermetproyekt [expansion uncertain], USSR Ministry of Ferrous Metallurgy: Let me just note that implementation of the "metal content" program depends not just on metallurgists, but on other branches of industry as well. For example, the chemists should organize the production of plastic gas pipe. But now we have been ordered to organize the production of 1.5 million tons of gas pipe per year. We are beginning to look for resources and to divert them from the reequipping of the industry. We are all for decreasing or stabilizing the production of metal in what we say, but in what we do we keep loading down our metallurgists, based on the interests of the moment.

V. Golyayev, deputy director, Central Scientific Research Institute of Ferrous Metallurgy, USSR Ministry of Ferrous Metallurgy: I would like to recall some facts: In 1986, 710 million tons of steel were produced in the world—exactly the same as in 1974. The share of steel production represented by the developed capitalist countries dropped from 58 to 40 percent in that time, the USA dropping from 19 to 10 percent.

Under these conditions, the Americans are developing a "strategy for the survival of ferrous metallurgy." They have an annual conference by that name. Soviet metallurgists participated for the first time in the 3rd conference, in June 1988. The recommendations of the conference included reconstruction of the industry, rapid introduction of new technology and new steels, improvement in the quality of metal products, increasing the share of continuous casting to 90 percent and so forth—important recommendations for Soviet metallurgy as well.

In our country the production of cast iron, steel and rolled products increased between 1960 and 1975 by a factor of about 2.2, while the production of pipes increased by almost 2.8 times. In 1975-1990, the growth rate will amount to 10-20 percent, 44 percent for pipe alone. Then, up to the year 2000 production will stabilize, with pipe increasing by about 17 percent.

In ferrous metallurgy, a long-term program for reequipping the industry is under way. We're giving priority to reequipping rolling mills and steel-making plants. But even so, the classical technology of steel production will be around until the end of the century.

Question from the hall: But what about revolutionary technologies?

V. Golyayev: The metallurgical "ore—steel" process, using no cast iron, no blast furnace, will be broadly introduced. One version of this process is now being used successfully in Staryy Oskol.

The new "pour and roll" process allows us to combine pouring and hot rolling of metal into a single process. This energy-saving, lower labor cost technology has now been officially accepted.

The Shoals of Reconstruction

V. Antipin: By the year 2000, we are supposed to decrease the metal content of national income to about half. Both world metallurgy and Soviet metallurgy have started down the path which ferrous metallurgy must follow to achieve this.

V. Filatov: Technical retooling of the industry basically means giving the plants the equipment they need. To organize continuous casting of steel and reequip rolling plants in the 13th five-year plan will take 1.8 billion rubles worth of equipment. But our machine builders, the Ministry of Heavy and Transport Machine Building, the Ministry of Instrument Making, Automation Equipment and Control Systems, the Ministry of the Electrical Equipment Industry and the Ministry of the Machine Tool and Tool Building Industry, have only promised us 1.1-1.2 billion rubles worth of equipment. That means that the problem about deliveries of the other 30 percent of our equipment has not yet been resolved.

Another important problem is the finishing of all metal products. Where are we to find the finishing equipment? For two years now we have been trying to get an answer from the Ministry of Heavy and Transport Machine Building on this question, but we still don't have it. The

State Planning Committee will probably have to get involved. Unless we solve this problem, there's no use talking about technical retooling or implementing the "metal content" program.

S. Anisimov, deputy chairman, USSR State Committee for Material and Technical Supply: It seems to me that the USSR Ministry of Ferrous Metallurgy is forcing its plants into a corner. They don't always properly distribute the equipment they receive from the Ministry of Heavy and Transport Machine Building or from imports. In some cases, the equipment lays around warehouses for years, in others it is sent to new construction sites rather than reequipping and reconstruction projects. The Nikopol Southern Pipe Plant made a nationwide stink. It was a reliable partner for other plants. But the Ministry of Ferrous Metallurgy got carried away with constructing new shops at the plant, while the older shops just gradually went to rot. Couldn't the ministry even see that? It's quite clear now that if the equipment in the hot pipe rolling shop isn't replaced soon, there will be even more frequent interruptions in the delivery of this very necessary product. And the state will be forced again and again to dig around for foreign exchange to make up the pipe shortage...

V. Antipin: Our 12th five-year plan was good. For example, we planned on 45-50 million tons of continuous cast steel. But we see clearly now that we won't make it. And not because the money wasn't provided or the technical documentation. There isn't any equipment! The industry only receives 40-60 percent of the equipment needed.

We have to create our own equipment with our own efforts. We have organized our own machine building main administration and we are making three continuous casting machines. That's us, instead of the Ministry of Heavy and Transport Machine Building. Our association is starting to manufacture defectoscopes, which are supposed to come from the Ministry of Instrument Making, Automation Equipment and Control Systems. I can give more examples.

Last January the pipe-rolling plant imeni K. Libknekht in Nizhnedneprovsk started up a ring-rolling section with a planned capacity of 120,000 tons of product per year. Its equipment, provided by Uralmash, is down more than half the time. This has cost the plant a 9 million ruble loss already.

At the Dneprpetrovsk Metallurgical Plant imeni Petrovskiy, a "550" mill which started operation late last year caused another 7.2 million rubles in loss during the first half of 1988. The reason—the new equipment doesn't work right.

When metallurgists deliver metal which is rejected, they have to make good the cost of the rejected metal. Why don't machine builders have any responsibility for their rejects?

M. Chertkov, chief state medical officer, Dnepropetrovsk: We have some complaints about equipment, particularly pipe rolling equipment. Everything produced makes more and more noise. The result is auditory neuritis. After that—vibration sickness.

V. Reshetov, department chief, All-Union Scientific Research Institute of Metallurgical Machinery, Ministry of Heavy and Transport Machine Building: Yes, the machine-builders cannot satisfy the demands of metallurgists for equipment. But it's no secret to anyone that virtually no machine building plants specializing in the production of metallurgical equipment have been constructed in this country since the Second World War. The Ministry of Ferrous Metallurgy now sends us extensive programs for the delivery of continuous casting machines, vacuum units, steel finishing installations and so forth. But the machine-builders don't have the capacity to make all this equipment fast enough to satisfy the Ministry of Ferrous Metallurgy. It's a vicious circle.

V. Filatov: If we don't change the relationships between machine-builders, planners, construction people and contractors, if we don't solve the problems of material supply and of issuing documentation in the course of construction, we won't be able to reequip the industry or keep up with the "metal content" program.

What should we do? Three cycles have to be combined at the same time— designing of equipment, issuance of documentation for construction and the construction itself. In other words, at the same time that the machine-builders develop the equipment, we have to formulate the design documents, and the construction people have to build right along with the development of the design documents. But this isn't being done. The only project where all three of these processes have been combined is in the aluminumizing installation at the Cherepovets Metallurgical Combine. We started working on it last year, and it will go on line next year.

At our other projects, we are working by the old way.

We have repeatedly pointed out the need for parallel project planning and construction, there have been commissions from the USSR Council of Ministers, but everything remains as before. The USSR State Committee for Construction Affairs, in order No. 751, arbitrarily forbade the builders to receive documentation from us after 1 July, even though a decree of the Council of Ministers stated that we have the right to issue documentation right up to the beginning of the plan year. The State Committee for Material and Technical Supply should also resolve supply problems not a year in advance of the beginning of a construction project, but while it's going on.

The Italians are presently helping us build a pipe plant—a collosal complex costing billions of rubles. By our estimation, we would have messed around with this plant for at least 8 years, but with them we'll finish it in three and a half years.

A. Solovyev, chief, Department of Capital Construction and Project Review, Yuzhmetallurgprom State Production Association: The builders have six priority industries which they must service first. But you won't find ferrous metallurgy on the list. Therefore, year after year, the builders fall further and further behind on the projects of our association. In the two years of this five-year plan, capital investments have lagged by about 200 million rubles. Maybe the State Planning Committee and the State Committee for Construction Affairs could put ferrous metallurgy back on the list of priority industries?

A. Kogadeyev: Priorities are determined on the basis of the significance of tasks which an industry must perform during a plan period. A priority may be put in the plans, but during their implementation it is frequently not met due to the unsatisfactory work of the people participating in the investment process—the clients, the builders and the machine-builders. During the past five-year plan ferrous metallurgy enterprises in the Ukraine failed to utilize 430 million rubles of capital investment called for by the plan. During the two years of the present five-year plan, as was just mentioned, some 200 million rubles have already not been spent.

Introduction of continuous steel casting is a high priority for ferrous metallurgy, and was included in the five-year plan. Today about 20 percent of the steel made in this country is made by that method, while in Yuzhmetallurgprom the figure is just 7 percent. We planned to introduce 41 continuous casting units during the five-year plan, including 11 installations in the Ukraine. Actually, in 3 years, of 15 installations only 7 will be put on line and of the 3 installations planned for the Ukraine, only 1 can be put on line. The continuous casting installations at the combines imeni Dzerzhinskiy and imeni Ilich are being built at an unsatisfactory rate, which is the fault, not only of the machine-builders and construction people, but also of the project engineers of the USSR Ministry of Ferrous Metallurgy, who did not supply the planning estimates on time. Therefore, the clients themselves are equally at fault for the reduced rate of construction at metallurgical plants.

V. Antipin: When the 12th five-year plan started, everybody was in the same position. But what now? Have a look at how things are going at Magnitka. The converter shop will start up next year, a new "2000" hot rolling mill is going up, the area is being prepared for a "2000" cold rolling mill. And all that in one five-year plan. That's because the leaders of the city and the oblast are involved in the reconstruction.

K. Nosov, general director, Krivoy Rog Metallurgical Combine imeni V. I. Lenin: A miserly 15 million rubles has been allocated for reequipping Krivorozhstal this year. When this five-year plan was being planned, measures for reequipping the combine were drawn up in the hope that we would get some state budget funds. Now they say: handle the reconstruction with your own money—and leave your goals as before. We would be glad to, but, for example, of the allocation for the combine they left us only 14 million. And the combine has 800 million rubles of fixed capital! Should we leave our equipment in this condition... Until reconstruction happens?

The Economic Aspect

As of 1 January of this year, ferrous metallurgy enterprises went over to self financing and self support. We can now draw the first conclusions concerning operation under the new management conditions. The most important is that even some debtor enterprises now regularly report 100 percent completion of agreements, making product above the plan. But that is now and what will happen in the next five-year plan? The immediate prospects are a subject for some alarm.

S. Anisimov: The question of proper allocation of metal received is acute right now. At many enterprises it is thoughtlessly wasted, converted to shavings, dumped into metal-intensive machines. A lot of it lies around in uncompleted construction for years, in above-standard surpluses, going bad. In the Ministry of Heavy and Transport Machine Building, for example, at the end of the first half year the surplus of finished rolled products was something over a 110,000 tons, a third greater than the planned transient reserve. And everyone is shouting about the metal shortage! And this we see at enterprises of khozraschet ministry.

The plants of the Ministry of Ferrous Metallurgy itself are doing poorly on saving metal too. Just as before they chase after the total output figures and sometimes fail to meet orders for effective types of rolled products. This is particularly true of the giant enterprises, where it is difficult to adjust production to respond to new consumer demand.

A. Kogadeyev: We could use the services of smaller metallurgical plants here. But there are so few of them.

V. Kirsanov, deputy director for economics, Plant imeni K. Libknekht: Isn't it time to give our enterprises permission to trade directly with foreign firms? Our pipe rolling plant imeni K. Libknekht, for example, could sell pipe or wheels abroad and use the money to buy good defectoscopes overseas and improve our product quality. As it is now, even if you have the foreign exchange, you can only get the right to buy, for which you pay more rubles. Why the double price? It should be one.

K. Nosov: Kabaidze spoke at the All-Union Party Conference. He spoke well ... but the machine-tool builders of Ivanovo must deal with conditions quite different from the metallurgists of Krivoy Rog. We have no rights. Last year, we sold semi-finished goods above the plan. They promised us we'd get an award for first quality category. Nothing happened.

The standards they have imposed on us are ludicrous: 13 kopeks to the ruble. No matter where we turn, no matter who we show that this is not enough, nothing changes. Even though the combine fills its orders 100 percent, has 10 million rubles of above-plan profit, its financial position is catastrophic. It is going bankrupt.

Or take for example the cooperatives. A stream of workers has been flowing to them from the enterprises. Why? Because the conditions of labor organization and wage fund formation are totally different. But we, a large state enterprise, find ourselves on unequal footing with a cooperative, since everything is rigidly planned for us, established once and forever, you can't budge a thing.

N. Lyakishev: Prices for metal represent a very important question. Everyone knows that our metal is 2.5 times cheaper than foreign metal. Or, speaking honestly, not 2.5 times, but 10 times. We sell metal for 55 kopeks per kilogram, then buy equipment at 11 rubles. How is ferrous metallurgy supposed to develop under these conditions?

The director of Krivorozhstal, K. Nosov, was right when he said that ferrous metallurgy will soon become unprofitable. Price formation in our industry should be just like in instrument-making and machine-building.

K. Nosov: With one hand we vote for quality metal, while with the other hand we sign a directive to decrease metal quality. Here's another example. Next year we have been told to decrease the consumption of cast iron in our steelmaking shop, which is already using reoxidized metal. The consumption of 750 kg of cast iron per ton of converter steel was not confirmed by any engineering measures, nobody works that way. It turns out that we will reduce the consumption of cast iron but the consumer will get lower quality metal.

Question from the hall: Do you need that planning indicator,consumption of cast iron per ton of steel, at all?

K. Nosov: Of course not. That's our internal business. But it's planned!

...And for Clear Skies

Not long before the discussion at Dnepropetrovsk, our newspaper printed a report under the heading "The Heavy-Duty Version," which discussed various versions for the reconstruction of the Dnepropetrovsk Metallurgical Plant imeni Petrovskiy. The authors of the report fought for an ecologically pure version, elimination of all production facilities at the plant except the rolling mill, and criticized the USSR Ministry of Ferrous Metallurgy and Ukrainian Council of Ministers, who insist on the retention of the full metallurgical cycle.

Clearly the participants in the discussion could not bypass this newspaper item. Furthermore, very heated arguments have developed around it. We won't repeat all the details of the discussion, since the theme of the discussion goes far beyond the ecological problem. But the conversation showed that the ecological aspects of the future development of ferrous metallurgy concern everyone.

S. Pliskanovskiy: The share of the harmful emissions from Yuzhmetallurgprom Association enterprises in Dnepropetrovsk Oblast is about 24 percent and about 15 percent in the oblast center. By 1995, harmful emissions will be decreased by 40-50 percent, and our enterprises will no longer dump water into natural bodies of water.

S. Shelomov, chief, Dnepropetrovsk oblast inspectorate, Ukrainian State Committee for the Protection of Nature: Our oblast takes second place in the republic for the quantity of harmful emissions, 70 percent of which are attributable to enterprises of the Ministry of Ferrous Metallurgy. Directive documents forbid construction of new or expansion by new construction of existing industrial enterprises in 20 cities of the republic, including Krivoy Rog, Dneprodzerzhinsk and Dnepropetrovsk.

M. Chertkov: Labor safety problems are coming to the fore. We see our task as improving the working conditions of metallurgists. The production association and the ministry both need to change their psychology on this question.

How can there be talk about new construction in Dnepropetrovsk? And the reconstruction of the plant imeni Petrovskiy (don't close your eyes!) actually amounts to new construction. Do you know that in Leninskiy Rayon of the city, where Petrovskiy is located, morbidity is 1 ½ to 3 times greater than in the clear rayons!?

The metallurgists are sure that no one will shut down their plant. No, comrades, it's time to give up the old stereotype that metal is more important than people's health. Enough already of talk about improving the ecological situation, it's time for the Ministry of Ferrous Metallurgy to move from words to deeds, to change its positions.

V. Antipin: The position of the Ministry of Ferrous Metallurgy is clear: We are in favor of renovations at the Plant imeni Petrovskiy, preserving the full metallurgical cycle. The new equipment and technology will significantly improve the ecological situation in the city.

A. Kogadeyev: Even today, the metallurgical industry is spending about 60 percent of its capital investment on reconstruction and reequipping of existing enterprises. Ecological problems are being solved without fail at the same time. Physically worn and obsolete units which cannot be economically modernized are taken out of use. Over the past decade, old open-hearth shops have been shut down at Yenakiyevo, Konstantinovka, Makeyevka, Dneprodzerzhinsk, at the Combine imeni Ilich, a bessemer shop at the Combine imeni Dzerzhinskiy, rolling shops at the Plant imeni Lenin in Dnepropetrovsk and

coal plants in Donetsk and Dnepropetrovsk. The USSR Ministry of Ferrous Metallurgy must develop measures to reequip existing facilities and units with the maximum utilization of already created fixed capital. This will liberate funds to solve social and ecological problems. The work must involve extensive participation of the worker collectives of the enterprises. Machine-builders must give their primary attention to the modernization of existing metallurgical equipment, or where this is impossible, to the creation of new equipment to be used in existing production areas.

V. Pilipenko: Here is a specific proposal concerning the ways for further development of the plant imeni Petrovskiy. Since two points of view have been clearly stated, I suggest we invite the USSR Council of Ministers to create an interdepartmental commission to look into the entire situation and make recommendations to the Council of Ministers. If this isn't done, we might get into a dead-end.

M. Chertkov: I support this suggestion completely.

We mustn't ignore the ecological problems of ferrous metallurgy. Not today, and certainly not tomorrow.

This "round table" involved people who know what metal is first hand—those who are called upon directly to choose the path of development of the industry. They are unanimous in their evaluation of the situation of ferrous metallurgy in our country. It is disquieting, however, that perhaps the most important question for today was left unanswered—when will ferrous metallurgy stop chasing after tonnage at any cost and concentrate primary attention on increasing the quality of products, when will our country take a leading position in decreasing the metal content of national income. A heated discussion arose around ecological problems. Here, as in reequipping of the industry, many unsolved problems remain.

But what do you, our readers, think of the situation in ferrous metallurgy, of the usage of its products, of the interaction of all elements of the industrial complex where metal is used? We hope that the discussion "Steel In the Year 2000" will be continued by scientists and specialists, workers and designers, representatives of ministries and departments, and plant directors.

Successful Operation of Lebedin Mining - Concentrating Combine

18420068 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian No 241, 20 Oct 88 p 2

[Article by Yu. Golovin, First Deputy General Director and Chief Economist, Lebedin Mining - Concentrating Combine, Gubkin: "A Model of Success"]

[Text] **The Lebedin Mining - Concentrating Combine is the first and presently the only ferrous metallurgy mining enterprise operating with the second model of khozraschet, which has been in use here since the first of the year. The combine today is a modern mining-concentrating facility. The numbers do not tell the whole story. However, the direct relationship between the improving results and the main factor which "makes it independent," khozraschet, is obvious. It is khozraschet which has permitted a second year of operation with costs below plan. I note at the same time that the planned production capacities have not yet been achieved. This is a minus for us. But whereas previously we only dreamed of reaching that level, it is now a task on the agenda of the day.**

Of course, "becoming independent" is not easy even today, let's be honest, in this period of radical economic changes. We were taught and trained to a false justice, called wage leveling. It is still alive today. But as soon as a collective becomes truly independent, even within the framework of the only partially consistent laws of today (for example, on state enterprises), the pillars of wage leveling start to fall. We have seen this in practice: a man finds his own potential if he is included in a system of obvious individual and group interests. In January 1987 we gave extensive rights to our shops, right up to approval of the management structure, staffing and wage regulations. We soon concluded: the main organizational force must be the contract.

First or Second?

Preparing for independent financing, we at first did not think deeply about the selection of the model. We believed in the policy sent down from above. Particularly since the collective contract systems which had been tried were close to the first model—What else? And how could we penetrate deeply where we had no experience and no instructions?

The choice of the second model was made after we analyzed various methods for the formation of the wage fund. For our repair plant, for example, we determined: the labor input here was much greater than in the main shops, but the wage fund would be several times smaller. What sort of khozraschet is that? The first model was clearly not suited. Our sympathies were inclined to the second model. With reflection its advantages have since become obvious. Just what are they?

A clear relationship of work to earnings and true self-financing of wages. Wages and bonuses are the most direct, effective stimulus, which everyone understands. I would also say that sanctions of various types are very effective stimuli, since they are paid to the victim not from far-removed funds, but rather right out of the pocket of the guilty party. The relationship of work to earnings for production and social development funds also has become obvious to every member of the collective. Both good and poor work have an irreversible influence on wallet.

A second advantage is cost reduction. Forty kopecks of each ruble of the cost of material resources saved go into the unified wage fund. Every member of a primary

collective (the brigade, for example) is made aware of the amount paid whenever a savings is achieved. The self-financing standards were made known to each brigade. Calls for economy, previously simply pro forma, have taken on a real attraction: save and receive.

The cost-cutting properties of the model also appear in the new-found interest in saving on the services of subcontract organizations. When the budget will support you, why be economical? Furthermore, you must spend all the money allocated for an item, or next year the budget will be cut. The first model provides no stimulus for seeking out internal reserves: as before, it is better to give work to an outside subcontractor, since work done in house is not reflected on the report and the wage fund will be used up besides.

The third advantage is the active reaction to product quality and to the completeness of raw material utilization, which is particularly important for a mining facility. Calculations have shown that reasonable expenditures for this purpose will be fully repaid. Once again, everyone wins, including every worker: of every ruble of additional payment for the quality of the ore, concentrate or pellets, 40 kopecks are put in the wage fund of the collective.

The second model permits active development of the social projects of the enterprise, finally putting an end to the residual principle of financing this important area of life.

Our new life started in January. Not long ago. But even this short time allows us to see the first results, to note some trends. And with so many indicators "in the black," it could hardly be chance.

For example: the volume of product sold, the gross income, yield on capital, labor productivity and product quality have all significantly increased. The state order has been completely fulfilled. All structural subdivisions of the combine are operating rhythmically and stably. The cost of all types of products has just as clearly and significantly decreased.

The rates of growth of labor productivity have tripled in a half year. This had never happened in the history of our enterprise. Profit above plan amounted to 7.8 million rubles. This also for the first time. Finally, savings of material costs have reached 5.4 million rubles.

The Common Denominator

Self financing. This common denominator of all measures has created an entire mechanism of interest, responsibility and results.

This everyone knows. But how does self financing operate at the structural subdivision level?

Two paths have been opened: redistribute the overall end result (khozraschet income) among the subdivisions with an unavoidable share of subjectivism. Or use a continuous (skvoznoy) version with a standard for the distribution of income in each structural subdivision as the basis.

Of course, the second path is preferable. But its implementation requires at a minimum planned-accounting prices to permit an objective distribution of the profit. The problem has now been solved by reducing all the types of resources used by the shops to its main type—labor in its value form. I can't tell you that the problem has been solved with scientific strictness. However, we have been able, using a single criterion, to measure the contribution of each subdivision (and within them, of each man) to the end result, khozraschet income, without obvious distortions. The basic principle of social justice, "to each according to his labor," has been achieved in the sense that more and better work means higher pay.

In a word, the standard method of distributing income used for the combine as a whole has become continuous—it is used in the same form for all subdivisions—administrations, shops, labor columns, sections and brigade-sections.

But what about the primary unit—the brigade? Where the numbers are small and bookkeeping impractical? We have found an answer.

Books are kept for the brigade-sector (a large enough subdivision). Small brigades (8-9 men) form part of a section or brigade-section with the rights of elements (zveno) and fall within khozraschet. The production volume and their share of the state order is precisely planned for them and the standards for consumption of material resources and other section economic standards are given them.

The unified wage fund is determined on the basis of the factor of the labor contribution to the overall results. This factor considers the volume and quality of production, the funds and labor resources utilized, savings of material costs, and managerial competence (the balance [saldo] of fines). These indicators are accounted for in personal effectiveness accounts.

Individual earnings within a brigade or shift are distributed by the entire collective or by the brigade council on its behalf based on the labor contribution factor. The labor contribution factor is recorded daily, which was previously impossible. Either the entire wage fund or only its incentive portion is distributed, as decided by the collective.

The cumbersome system of awarding bonuses as we used it for many years has now disappeared from the scene. It has been found that its chief defect was wage leveling. The basic principle now is "earn it, you'll get it."

I won't try to tell you that the demise of wage leveling was universally applauded. It has its proponents even today. Both among managers and among workers. They had become accustomed to dipping out of a common pot while looking for a bigger spoon. How could they applaud the new ways? Where democracy and self-administration are stronger, the struggle against wage leveling is easier and has less conflict.

The role of the plan and of the criteria for evaluating activity are now seen differently. The standards are starting to govern the economy.

Standards, khozraschet income and other categories do not abolish competitions (sorevnovaniye). A collective's labor quality factor is used to find the true winner of a competition and to compare a wide variety of indicators. This factor considers four areas: production activity, economic work, performance discipline and the social development of the collective.

Here is a specific example. The pelletizing plant, out of the entire state order system, failed to meet the quarterly assignment for the output of consumer goods. The labor quality factor fell below 1. As a result, the wage fund was decreased by 23,000 rubles, or 4 percent. The shop and section leaders lost 30-50 rubles pay, up to 20 percent of their salary.

Was this effective? Yes. Effective steps were taken very quickly not only in terms of the output, but also in terms of the sale of dried milled chalk, which is not in great demand.

The conversion of engineering and technical personnel to khozraschet is a problem. With a line worker, everything is clear: he is a part of the contract brigade. But the management apparatus, the departments and services of the enterprise? How can we measure their "product"—management decisions? We're testing one approach. It's based on a shop principle of standard distribution of income. It is defined as the remainder after subtracting material costs from the value of a hypothetical management product. Economic answerability to the contract collectives for fulfillment of contract obligations is expressed in the form of fines from the khozraschet income. That is, responsibility is consistently maintained by the wallet (the wage fund is decreased). The wage fund is distributed among departments and services according to the labor contribution factor. And this is not just empty words. In May, the social development department did not cope with the plan indicators. The labor contribution factor was 0.96. Accordingly, the wage fund was decreased by 160 rubles (8 percent), or 25-30 rubles per worker.

Unanswered Questions

You're wrong if you think that good results have now become automatic. It is now harder and riskier to work here. The collective has found itself rigidly dependent not only on the effectiveness of its own efforts, but also the good or bad work of those elements around it (I would note, first of all, the collectives under the Ministry of Railways), as well as superior management levels, both local and central. The second model has not yet given us true independence. Even a quick look at the plan for computation and distribution of gross income will show the reader that we are quite rigidly bound by the standards.

Let's look at another sore spot: the state order. For us, of course, it represents 100 percent. But why? What sort of independence is it if a collective does not have the right to manage even a portion of its own product?

True, you can't abandon the state order completely. It determines "when, to whom and how much." But for now a competitive basis for orders is still a long way off. The day of economic competition has not dawned. You can't do "more" (your designated consumer won't take it—your costs just go up) and nobody particularly needs "better" (the state order gives you the right to market products of the lowest quality). The paths are firmly set, you can't make direct connections. Go out into the foreign market? This is an obstacle which can be crossed only through the Chairman of the Council of Ministers.

The inability of a client to pay causes serious complications in the financial position of even a well run enterprise. You would think that one should consider a product sold when it is shipped. And if the consumer has no money, let a bank or superior organization provide credit on a reimbursable basis at an appropriate interest. Are we pounding on an open door? Are the banks obligated to do this? Yes, there are decrees about this. But they are not honored. The banks don't want to be bothered about this. We see once again, the bank is not there for us, we are here for the banks...

No Mutual Gain

There is also no answer to the question, how to build relationships with local agencies and with agriculture, although the problems have long awaited solution. But for now the principle is "you got your orders—do it," although this is contrary to khozraschet. The financial and legal aspects of this have not been fully set right. To explain our concern, I need but note the cost of "patronage assistance" which costs us 750-800,000 rubles per year. What's behind this large sum? Here's what. Under the old conditions we are told to provide 250 machine operators, weed and harvest 1,200 hectares of beets, 300 hectares of potatoes and to build housing and social and cultural projects in the villages valued at approximately 1.5 million rubles. And up to another 200 of our workers were used on urban projects as construction workers... I reject the idea that we must return our debt to the villages, etc. Are we against it? We are against the fact that under various pretexts the principle of khozraschet relationships is held back, thus demonstrating that one can still live in the old way.

No khozraschet model can stand up to such massive noneconomic attacks. And the sooner this truth reaches the highest echelons of management and is converted to the appropriate standards, the better it will be for society and for each member of a collective. Dare I set forth the seditious idea that the second khozraschet model has not swept the nation because managers and workers are simply afraid to bankrupt themselves on the strength of various constantly operating distractions?

The role of the victor in the all-union socialist competition is somewhat paradoxical today as well. It is not so much that he actually must stimulate himself. When, after all the operations under a given "bonus" system are completed and the enterprise is awarded, let us say, a bonus of 60,000 rubles, the unified wage fund gets only half. And the other half? It seems to evaporate, since out of the khozraschet income reduced by these theoretical 60,000 rubles, after it is distributed according to the standards, a smaller fraction is available for payment. Our good work brings both smiles and tears. And all because we do not have the right today to divide the khozraschet income by areas of use. The Damocles sword of the standard ratio hangs over us even under the second model. Does this mean that khozraschet without the usual administrative limitations is still unthinkable?

Yes, successes, even appreciable ones, are clearly seen, though the mechanism needs more improvement in order that each member of a collective without exception day after day would indoctinate himself in khozraschet. However, these successes hardly mean that khozraschet has escaped the power of all kinds of restrictions. We have named a few of them here, those which most alarm us. But they surround every mine worker, enterprise collective, and in this way cause losses to society. We cannot accept them.

UDC 629.113-043.13

New Materials for New Automobile Equipment

18420007b Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian
No 5, May 88 pp 34-35

[Unsigned article: "New Materials for New Automobile Equipment"]

[Text] **To ensure efficient utilization of material, fuel, and energy resources, our industry's scientific-research institutes, together with the automobile and metallurgical plants, are working not only on improvements of automobile equipment designs but also on the development and use of new materials. Specifically, these materials include high-strength and low-alloy cast irons, spheroidal graphite cast iron (the latter is used in the manufacture of crankshafts and camshafts, wheel hubs, mount brackets, transmission casings, differential casings, etc.), low-alloy sheet and plate steels, and plastics (according to calculations by specialists, replacement of steel body panels by plastic panels lowers the automobile weight by 40 percent, that is, by the same percentage as that achieved by the use of aluminum).**

Let us consider some of the most typical of such materials. They were all shown at the anniversary exhibition.

Iron and Ferrous Alloys

At the Kiev Motorcycle Plant, cast motorcycle parts were made until recently from two grades of cast iron, and a considerable part of these parts, particularly small ones, required annealing. However, now the situation has changed: the NIIATM [Scientific-Research Institute for Automobile and Tractor Materials] specialists have developed and introduced in the plant's foundry a new alloying and inoculation technology, which has made it possible to produce the entire assortment of cast motorcycle parts from a single melt, to stabilize the hardness, microstructure, and the extent of chill of new cast iron, to reduce the number of defective parts, to lower the consumption of scarce alloying additives (including metallic nickel), to fully dispense with heat treatment of small castings, and to save up to 500,000 kilowatt-hours of energy a year.

The annual economic effect is 71,000 rubles.

For the production of valve seats, our industry has developed and is introducing into production, for example at the KamAZ [Kama Automobile Plant], a low-molybdenum white iron containing 0.5-1.5 percent molybdenum and 0.5-1.5 percent vanadium. At a hardness of the castings of Rockwell 45-50 (after tempering at 990 K, or 720 °C), valve seats made from the low-molybdenum cast iron show a 20-percent better machinability than those made from an iron containing 4.5 percent molybdenum. Their wear resistance in engines is the same as that of the valves made from iron containing 4.5 percent molybdenum.

The use of this cast iron will save 60 tons of ferromolybdenum per ton of castings. The economic effect at the KamAZ should be at least 60,000 rubles a year.

The iron was developed by the NIIATM and the KamAZ.

High-strength hot-rolled plate steels 18G1KhFTYuD and 18G2KhFTYuDR are intended for the production of parts (for example, frames, large-truck bodies, etc.) serving under difficult conditions and at low temperatures (up to 200 K, or -70°C). They show an increased strength while retaining a high ductility at low temperatures:

	18G1KhFTYuD	18G2KhFTYuDR
Yield Point, MPa	600	650
Ultimate tensile strength, MPa	720	750
Elongation, %	14	16
Bending angle, degrees	180	180

Quenched and high-temperature tempered plates made from these steels have a high resistance to crack formation and extension during subsequent plastic working,

and the plate structures show a high weldability. The plate thickness is reduced by an average of 10-15 percent compared to the usual steels.

The economic effect from the introduction of these steels, for example at the Belorussian Automobile Plant, has amounted to 400,000 rubles a year, and it will exceed 1.5 million rubles when the use of these steels increases. Also, unlike foreign steels having the same strength and ductility, the new steels developed by the NIIATM do not contain very scarce materials such as molybdenum and niobium.

The steels are produced by the Orsk-Khalilovo Metallurgical Combine.

Low-alloy steels, having a minimum yield point of 294 MPa in the cold-rolled state and 343 MPa in the hot-rolled state, have higher ductility properties than the well-known steels 09G2 and 12GS. The ultimate tensile strength of the new steels is not less than 441 MPa. The elongation at fracture of cold-rolled steels 08GSYuF and 08GCYuT exceeds 28 percent, while that of steel 07GSYuF exceeds 26 percent. In the hot-rolled state the elongation of steel 08GSYuF exceeds 32 percent and that of steels 08GSYuT and 07GSYuF exceeds 26 percent.

The high ductility of these steels was achieved by a thorough deoxidation with aluminum and alloying with a combination of manganese, silicon, and vanadium or titanium. This makes it possible to use them for the manufacture of automobile parts by cold stamping and drawing and bend-forming (door posts, reinforcing parts, mounting brackets, axles, angles, frame parts, etc.).

The new steels are also suitable (and even better than steels 08Yu and 08kp) for stamping of more complicated parts. As a rule, a change-over to these steels does not require changing of the stamping equipment; it is sufficient to reset the stamping tools and to use special high-efficiency lubricants.

Cold-rolled steel 08GSYuF in thicknesses from 0.8 to 2.5 mm is produced by the Cherepovets Metallurgical Combine, cold-rolled steel 08GSYuT in thicknesses from 0.7 to 2.5 mm by the Novolipetsk Metallurgical Combine, and steel 07GSYuF, in thicknesses from 1 to 3 mm in the cold-rolled state and in thicknesses from 3 to 6 mm in the hot-rolled state, by the Zaporozhstal Combine.

The steels were developed by the NIIATM, the Ferrous Metallurgy Institute imeni I. P. Bardin, the Cherepovets Metallurgical Combine, the Zaporozhye Machine-Building Institute, and the Zaporozhstal Combine.

The steels are used at the ZIL [Moscow Automobile Plant imeni I. A. Likhachev, the AZLK [Moscow Automobile Plant imeni Lenin's Komsomol], the GAZ [Gorkiy Automobile Plant], the ZAZ [Zaporozhye Kommunar Automobile Plant], and other plants of our industry, where the annual economic effect is about 1.5 million rubles and the savings of rolled metal products is 5,400 tons.

A boron-containing steel, 20G2R (TU 14-1-2811—79), has been developed for the manufacture of fasteners by cold extrusion and upsetting. It has high ductility properties and strength, which makes it possible to substitute it for alloyed machine-construction steels 40Kh, 19KhSN, 38KhGNM, and 40KhN and to reduce the number and duration of heat-treatment operations. The use of steel 20G2R in closed-die cold forging of bolts, nuts, screws, and studs increases the coefficient of utilization of ferrous-metal rolled products from 0.3 to 0.5 in machining and up to 0.8-0.95 in cold upsetting. This also improves the quality of the parts (mechanical properties, manufacturing precision, etc.) and saves scarce alloying elements (chromium, nickel, molybdenum). The unit cost of rolled products is lowered (depending on the material being replaced) by 30-80 rubles per ton.

The steel was developed by the NIIATM, the Avtonormal Plant in Belebey, and the Krasnaya Etna State Plant.

UDC 539.379.4:620.178.2:669.15-194.2

Influence of Preliminary Bending Deformation on Brittle Fracture Tendency of Low-Carbon Steel

18420055b Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 6-8

[Article by I. N. Khristenko, I. N. Dryukova and L. S. Mednikova, Ukrainian Scientific Research Institute of Metallurgy]

[Abstract] A study is presented of the influence of aging conditions of low carbon steel deformed by bending on brittle fracture tendency. Studies were performed on specimens made from 5-12 mm thick St3sp and St3ps steel deformed by bending at normal temperature to 45 and 60° angles or at 900°C to 90 and 120° angles, then straightened at normal temperature. The 90° bending and straightening was found to have the same influence on yield point as 10-12 percent deformation. It is calculated that bending by 45° causes an average deformation of the metal fibers by 6.3 percent, 60°—7.0 percent. Preliminary deformation by bending causes embrittlement of the metal just as does extension, and subsequent aging and tempering increase the process. References 5: all Russian.

UDC 620.18:669.15'26'24'28-194

Influence of Chromium and Nickel on Structure Formation Through Cross Section of Large Cr-Ni-Mo Steel Forgings

18420055d Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 16-19

[Article by V. G. Sorokin, Ye. P. Vorobyeva, M. A. Gervasev and N. A. Adamova, Central Scientific Research Institute of Metals (TsNIIM), Sverdlovsk]

[Abstract] A study was made of the influence of chromium and nickel on structure formation through the cross section of forgings 50-800 mm in diameter, made of medium-carbon chrome-nickel-molybdenum steels hardened in oil. Thermokinetic diagrams of the breakdown of supercooled austenite were constructed for all the steels studied. Structural diagrams are used to determine the concentration intervals of the most intensive influence of chromium and nickel on the formation of favorable martensite, martensite-bainite and bainite structures: 0.4-1 percent Ni and 1.2-2.0 percent Cr. The variation in supercooled austenite stability upon continuous cooling as a function of chromium and nickel content is nonlinear. Computerized mathematical modeling was used to calculate the structural and temperature fields formed through the cross section of large forgings when quenched in oil and the results of the computation are summarized as structural diagrams showing the influence of chromium and nickel. Varying the chromium and nickel content can obtain uniform structures in forgings of some assigned diameter. Chrome-nickel-molybdenum steels with 2 percent Cr and 1 percent Ni are recommended as replacements for high-nickel steels in forgings up to 800 mm in diameter. References 15: 12 Russian, 3 Western.

UDC 669.14.018.293:669.295+669.781:539.2

Influence of Complex Microalloying With Titanium and Boron on Structure and Properties of 14G2 Steel

18420055f Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9 Sep 88 pp 23-25

[Article by V. V. Shchigolev, G. S. Yershov, A. A. Sotnik, V. V. Akulov; Institute of Materials Science Problems, Ukrainian Academy of Sciences; Donetsk Metallurgical Plant imeni V. I. Lenin]

[Abstract] A study is made of the influence of combined microalloying with titanium and boron on the cold resistance of hot-rolled sheet steel type 14G2 (composition, in percent: 0.13 C, 1.4 Mn, 0.3 Si, 0.024 S, 0.021 P, 0.24 Cr, 0.09 Ni, 0.008 Al, 0.01 N), as well as the degree of contamination and the distribution and type of nonmetallic inclusions, which influence the technological and usage properties of the metal. The cold resistance was found to increase significantly when 0.026 percent Ti and 0.0014 percent B were added, as a result of the improvement of the microstructure, decrease in the volumetric content and dimensions of inclusions, changes in their composition, leading to a reduction in the formation of elongated inclusions during rolling. Increasing titanium and boron concentration to 0.049 percent Ti and 0.0060 percent B resulted in the formation of anonuniform structure, an increase in the overall contamination of the metal and the formation of large numbers of embrittling film segregations of titanium carbonitrides at the grain boundaries, decreasing the cold resistance of the steel. References 4: all Russian.

UDC 669.14.018.24

Increasing Structural Strength of 09G2S Steel With Ferrite-Martensite Structure

18420055e Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 19-23

[Article by L. I. Tushinskiy, Ye. N. Mironov, L. B. Tikhomirova and V. A. Ananin; Novosibirsk Electrical Engineering Institute; Novosibirsk Institute of Railroad Transport Engineers]

[Abstract] The possibility of improving the properties of hot-rolled 09G2S steel in 8 mm sheets with ferrite-martensite structure by increasing the strength of the ferrite component by reducing its dimensions and creating substructures by means of controlled thermoplastic hardening was studied. Specimens of hot-rolled 09G2S steel were held at the austenitization temperature of 900°C, cooled in the intercritical temperature range to 680°C, held at this temperature to allow the process of ferrite segregation from the austenite to be completed, then quenched in water. Holding at 680°C yields a ferrite-austenite mixture with about 30 percent austenite by volume, which is fully converted to martensite upon quenching. Regulated thermoplastic treatment includes a combination of deformation in the austenitization stage to break up the two-phase structure and in the intercritical interval to form substructural dislocation structures. All specimens were then quenched in water and tempered at 200°C for 1 hour. The treatment yielded good structural strength, indicating its promise for the manufacture of construction structures and pipe. Controlled thermoplastic treatment as described above doubles the threshold stress intensity factor and decreases the fatigue crack growth rate under cyclical loading approximately by a factor of 1.8. Tensile strength increases from 800-880 N/mm^2, yield point from 540 to 650 N/mm^2 and reduction in area from 17 to 19 percent. References 10: 5 Russian, 5 Western.

UDC 621.785.3

Energy-Conserving Technology for Preliminary Heat Treatment of Large Forgings

18420055g Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 41-45

[Article by Yu. A. Bashnin and E. B. Mernik, Moscow Evening Metallurgical Institute]

[Abstract] A new technology of preliminary heat treatment of type 38KhN3MFA steel is suggested, involving thermal cycling and rapid final cooling. Thermal cycling includes 3 cycles of heating to the intercritical interval temperature and cooling to a temperature 30-50°C below the Ar_1 point with isothermal holding. The multiple thermal cycling has a diffusion pump effect, accelerating the diffusion of hydrogen from the forging and allowing the total time of antiflaking treatment to be reduced. Brief heating above the Ac_3 point at 840°C for 3 hours, cooling to 100-150°C and tempering at 650°C improves the workability of the forgings by cutting. Regulated cooling is also used to achieve a level of residual stresses close to the level after complete cooling with the furnace. The mechanical properties of forgings following the new treatment are equal to those following the traditional treatment. The economic effect of the introduction of the new treatment has been a savings of about 200,000 rubles in 2 years. References 7: all Russian.

UDC 621.74.043.1:620.17:669.14

Use of Intensive Heat Liberation During Crystallization and Cooling to Improve Steel Properties

18420055h Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 45-49

[Article by S. Ye. Kondratyuk, B. B. Vinokur and L. A. Sokirko, Casting Problems Institute, Ukrainian Academy of Sciences]

[Abstract] The poor mechanical properties of cast steels and casting defects result from the casting technologies used and the use in most cases of steels which were developed for deformation. Slow cooling of the metal during crystallization and cooling of the casting causes the formation of a coarse dendrite structure, large primary structures, well developed liquation, segregation of excess phases on crystalline boundaries. Most of these casting defects can be eliminated by the use of water-cooled copper chill molds in which the mean rate of heat liberation is 500 K/sec near the surface in the interval from the pouring temperature to 200°C. The great reduction in dendritic structure size and the ability to regulate the direction of crystallization create conditions favorable for resistance to operating loads, resulting in improved strength, ductility and impact toughness. This has been verified experimentally, and the studies have served as the basis for development of a new technology for production of broaching dies by casting rather than rolling and cutting. The new technology includes 6 operations instead of 18 and the mechanical working required is reduced by a factor of 10. Hardening of the die is no longer needed.

UDC 669.14:621.793.74

Impact Toughness of Type 45 Steel With Protective Coatings

18420054f Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 27 Jan 86) pp 85-88

[Article by L. I. Tushinskiy, V. A. Batayev, A. A. Batayev and Ye. N. Mironov, Novosibirsk Electrical Engineering Institute]

[Abstract] A study is made of the influence of protective coatings M2 and PG-SR4 on the impact toughness of hot rolled type 45 steel. Coatings were applied to one side of the specimen in a layer 0.7-0.8 mm thick. Tests were performed on specimens with a U-shaped notch at +50 to -60°C. Flat unnotched specimens were also tested at -196 to +500°C. In general, at 0-50°C the impact toughness was decreased by the coatings. The coatings made the specimens more brittle. The brittle coatings tended to restrict plastic deformation of the base metal. At lower temperatures, -40 to -60°C, the base metal itself is brittle and the coatings had little influence on impact toughness.

UDC 669.245'295:669.786

Nitriding of Nickel-Based Alloys With Various Titanium Contents

18420054g Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 23 Nov 87) pp 96-98

[Article by Yu. M. Lakhtin, Ya. D. Kogan, D. P. Shashkov and L. G. Petrova, Moscow Motor Vehicles and Roads Institute]

[Abstract] A study is made of the process of the nitriding of nickel-based alloys containing nitride-forming elements such as titanium. Alloys of nickel containing chromium, tungsten and cobalt, with a titanium content of 1.7-3.4 percent by mass, were studied. The specimens were nitrided on a laboratory installation in an atmosphere of pure nitrogen. The temperature was varied from 1000 to 1200°C and its nitriding time from 5 to 15 hours. The microhardness of the nitrided specimens was studied as a function of nitriding conditions. Microhardness was found to increase with increasing titanium content, although the thickness of the diffusion layer formed decreased. Production of thick diffusion layers consisting of thermodynamically stable nitride particles

distributed in a solid solution can increase the heat resistance of the material. The increase is greater, the higher the temperature and longer the time of nitriding, due to the increased diffusion layer thickness. References 5: all Russian.

UDC 669.018.(27+45)-15

Manufacture of High-Strength Strips of Martensite-Aging Steel

18420054h Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 6 Oct 87) pp 98-103

[Article by S. V. Grachev, A. S. Sheyn, S. V. Pavlova and A. S. Mylnikov, Urals Polytechnical Institute]

[Abstract] This article studies the production and properties of a strip spring material of martensite-aging steel with the following chemical composition, in percent: 0.07 C, 10 Cr, 8 Ni, 8 Co, 4 Mo, 1 Ti and 0.17 Al, selected so that after hot rolling the structure of the steel consisted of martensite and austenite, while after cold rolling with approximately 50 percent deformation the structure would become single-phase martensite, yielding good plasticity. Hardening from 900°C is recommended as a softening intermediate treatment for semi-finished goods of this steel, maximizing plasticity. Aging at 550°C for three hours is also recommended. References 9: all Russian.

UDC 669.14.018:669.516

Influence of Slight Arsenic Content on Mechanical Properties of Low-Carbon and Low-Alloy Steels

18420054i Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 25 Sep 87) pp 103-105

[Article by M. A. Shumilov, L. V. Matviyenko and V. A. Ogurtsova, Zhdanov Metallurgical Institute]

[Abstract] Some 25 years ago it was predicted that after 15 years of aging the concentration of arsenic in certain steels could increase to 0.03-0.05 percent. The authors undertook a chemical study of sheet steels manufactured at two steel plants and found that the concentration was not over 0.014 percent in three types of steels tested. The arsenic content in the steels tended to decrease strength while increasing toughness. However, the entry of up to 0.015 percent arsenic with metal scrap into low-carbon and low-alloy steels has little influence on mechanical properties. References 4: all Russian.

UDC 669.046:539.8

Stress State of High-Pressure Chambers Made of High-Speed Steels

18420054j Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 17 Mar 88) pp 105-108

[Article by A. F. Sofroshenkov, A. V. Khegay and V. I. Kulakov, Siberian Metallurgical Institute]

[Abstract] The stress-strain state of two different high-pressure vessel inserts with different amounts of lateral supporting pressure is calculated. In the first (standard) chamber, the supporting edge is adjacent to the pressure volume. The second (suggested) type of chamber is made as a cone of revolution with an angle of 3°49' and a maximum diameter of 35 mm. The pressure volume is a spherical segment with a radius of 12.5 mm. The supporting edge is made as conical surfaces, located between the edge of the pressure volume and the edge of the side surface of the chamber. Finite-element discretization of a fourth of the axial cross-section of the insert was performed. Some 30 percent greater strength reserve was found for the suggested chamber form. Photoelasticity studies of the stress state were also performed on autoclave models made of optically active materials in 1:1 scale. The stress picture observed was close to that calculated. More uniform distribution of stresses and lower stress were observed in the suggested chamber. References 8: 7 Russian, 1 Western (in Russian translation).

UDC 669.162.23

Influence of Heat Engineering and Technology Factors on Blast Furnace Blast Temperature

18420054k Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 14 Jun 86) pp 116-120

[Article by E. M. Goldfarb, deceased, T. P. Petrova and Yu. M. Fleyshman, Dnepropetrovsk Metallurgical Institute]

[Abstract] A set correlation model similar to one previously used in an analysis of the blast-furnace process was constructed using the data from examination of the major structural and operating characteristics of the air heaters of 52 Ukrainian blast furnaces. The dependent variable used was the blast temperature entering the furnace; the independent variables were the gas consumption for air heating, the air heater exchange surface, the length of the blast period, the temperature beneath the air-heater dome, the packing mass in the air heaters, the thermal equivalent of packing, enrichment of the blast with oxygen, specific consumption of natural gas, content of silicon in the cast iron, yield of slag and load of ore per ton of coke. The linear probabilistic model

generated can be used to examine the influence of engineering and technological factors on the blast temperature. Ranking of the factors according to their influence on blast temperature showed that the most important was the temperature beneath the cupola. To increase the blast temperature, it is most important to increase the thermal capacity of air heaters, the thermal equivalent of packing, to heat the combustion components and to eliminate factors limiting the temperature rise. References 5: 4 Russian, 1 Western.

UDC 621.9+621.778

Influence of Cold Deformation Method and Subsequent Annealing on ShKh15 Steel Properties

18420054l Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 15 Jan 88) p 149

[Article by V. Ye. Pilguk, V. A. Gorobets and Ye. L. Goncharova, Donetsk Scientific Research Institute of Ferrous Metallurgy]

[Abstract] A study is made of the influence of the technological processes used in the production of rolled steel shapes on the properties of the steel after deformation and subsequent annealing of ShKh15 steel. The results indicated that with identical deformation, the strength characteristics of drawn bars are somewhat higher than that of cold rolled bars. For the slight degree of deformation studied with practically identical strain hardening of the surface layer, the middle layers of the cold rolled metal have somewhat less hardening than in the drawn metal. Induction heating to 730°C softens the metal, more effectively following drawing. Strain hardening is retained in the cold rolled bars.

UDC 669.1.002:621.791

Structural Changes in Type 45 Steel Exposed to a Hot Gas Stream

18420054m Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 4 Jan 88) p 151

[Article by G. N. Morozova, Ye. A. Yakovlev and L. A. Dakhno, Chemistry and Metallurgy Institute, Kazakh Academy of Sciences, Karaganda]

[Abstract] A study is made of the structure and surface hardness of type 45 steel after surface heat treatment by exposure to a gas jet with a mean-mass temperature of 3600 K. Surface treatment was performed without melting, the temperature of the surface being above the phase transformation temperature. The heating rate of the steel surface was approximately 3000°C/sec, at 3 mm depth—400°C/sec, the cooling rate during hardening 400°C/sec on the surface, over 200°C/sec in the deeper layers. Metallographic study revealed several structural zones: a white, unetched layer of up to 8 μm, a martensite zone of up to 230 μm, an intermediate zone of up to 2.4 mm, followed by the basic ferrite-pearlite core structure. Selective etching showed chemical heterogeneity of the hardened layer, distortion of structural components and clear stress lines immediately beneath the white surface layer. References 2: both Russian.

UDC 669.15-194

Dynamic Recrystallization of Carbon Steel

18420054n Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 22 Oct 87) pp 152-153

[Article by V. P. Gorbatenko, A. L. Geller and L. A. Kuvichinskaya, Donetsk Polytechnical Institute]

[Abstract] A study is presented of the influence of temperature and deformation on the dimensions and shape of the austenite grain in type 35 steel. Blanks 24 mm in length were heated to 1200°C, cooled, then rolled at 0.8-1.0 m/sec in one pass, cooled in water and the initial austenite grains revealed. The time between deformation and cooling in water was not over 1 sec. Deformation with slight compression of about 7 percent caused an increase in grain size. Increasing the degree of deformation at all temperatures helped to break up the austenite grain due to the occurrence of recrystallization processes. Intensive dynamic recrystallization of the austenite in carbon steel by formation and growth of new grains was observed after rolling with over 20 percent compression at temperatures of 900°C or higher.

UDC 621.745:621.365.5

Production of High-Grade Cast Irons by Duplex Processes

18420024a Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 88 pp 3-5

[Article by R. L. Gleyzer, engineer, V. I. Tonkonozhenko, candidate of technical sciences, and A. P. Melnikov, engineer]

[Abstract] A comparative evaluation of three duplex processes for production of high-grade cast irons was made: 1) cupola melting followed by soaking in an IChTM-6 induction mixer with appropriate amounts of FS-25 or FS-45 ferrosilicon; 2) cupola melting followed by heating in an IChT-10 commercial-frequency induction furnace with appropriate amounts of ferrosilicon and agents controlling the final C,Si, and Mn content, 3)d induction melting in an IChT-10 commercial-frequency furnace followed by soaking in an IChTM-6 induction mixer with appropriate amounts of ferrosilicon and rare-earth metal. Production of high-grade cast irons by these methods can reduce not only waste of metal but also energy consumption, the latter by 0.5 percent per ruble's worth of the end product.

UDC 621.74.004.63:669.14

Effect of Rare-Earth Metal in Economy-Alloy Steel on Mode of Its Fracture

18420024b Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 88 pp 8-9

[Article by Yu. A. Shulte, corresponding member, UkSSR Academy of Sciences, L. B. Cherepinskiy, candidate of technical sciences, G. A. Byalik, candidate of technical sciences, A. A. Zhirov, engineer, and A. A. Kromchenko, engineer]

[Abstract] An experimental study of 35Cr06Si cast steel (0.34-0.37 percent C, 0.55-0.62 percent Cr, 0.68-0.79 percent Mn, 0.84-1.0 percent Si, 0.017-0.02 percent P, 0.035-0.41 percent Al) was made for the purpose of determining the effect of its modification by the addition of a rare-earth metal along with 0.1 percent deoxidizer (Al) on the mode of fracture and the dependence of this effect on the sulfur content. The steel was smelted in an induction furnace with sulfur content varied over the 0.006-0.028 percent range. Other nonmetallic inclusions were determined in accordance with the "L" ("cast") procedure and microfractograms were obtained on carbon replicas under a transmission electron microscope. A rare-earth metal was found not to form the typical fusible complex globules but inclusions, evidently of its oxide, along grain boundaries in steel with less than 0.015 percent S. The percentage of ductile fracture, closely interrelated with percentage elongation and percentage reduction as well the KCU impact value, was found to decrease with increasing sulfur content in the steel deoxidized with aluminum. The results indicate that addition of a rare-earth metal increases the plasticity and the ductility as well as the cold resistance of this economy alloy steel when the sulfur content is low.

UDC 669.162.2.042.1.004.69

Modernization of Valve-Cone Loading Device With Radial Charge Distribution

18420051a Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian No 3, Jul-Sep 88 pp 6-8

[Article by A. I. Lesnoy, V. N. Nikiforov, A. F. Rybtsov, V. V. Kaurov and E. N. Saliy, VNIImekhchermet, Donetsk Scientific Research Institute of Ferrous Metallurgy, Dnepropetrovsk Metallurgical Equipment Plant, Dnepropetrovsk Metallurgical Plant imeni G. I. Petrovskiy]

[Abstract] The authors' institutes have developed a glandless valve-conical loading device to reduce required maintenance and blast-furnace downtime. The funnel is placed in the sealed body of the feeder device, eliminating the unreliable gland seals. Use of the glandless device increases the quantity of cast iron produced by reducing nonproductive downtime of the equipment, decreases the cost of maintenance and repair, and increases the service life of the conical gas-sealing level. Elimination of the rotating funnel gland seal also decreases power consumption of the charge distribution process. The use of the improved device also decreases the height of the equipment and the cost of its installation and operation. The modernized unit will decrease the consumption of coke through improving the utilization of the thermal energy of gases by improving the distribution of the charge in the blast furnace. References 2: both Russian.

UDC 669.18.046:558.7.001.5

Use of Titanium Metal Concentrate in Steelmaking

18420051b Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian No 3, Jul-Sep 88 pp 12-13

[Article by Ye. M. Krivko, P. I. Chub, I. P. Rogachev, K. D. Ivchenko, V. I. Chumak and V. V. Senichkin, Dneprodzerzhinsk Industrial Institute]

[Abstract] Technological approaches were tested for introducing titanium-containing metal concentrate to alloy killed steel with titanium during pouring and for chemical sealing of rimmed steel. The advantage of titanium over aluminum is that with a content of up to 0.04 percent the deoxidation products are liquid. This combines low concentration of oxygen in the metal with good conditions for floating of the deoxidation products. A metal concentrate containing 13.8 percent titanium, the remainder primarily Al_2O_3, was used. The use of this concentrate was found to save more expensive ferroaluminum, improve ingot macrostructure, decrease contamination of the metal with nonmetallic inclusions, while changing their composition, decreasing the alumina content by a factor of almost 2. References 3: all Russian.

UDC 621.774.35:669.14.018.8

Progressive Technology for Producing Thinwall Pipe of Corrosion-Resistant Steels and Alloys

18420051c Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian No 3, Jul-Sep 88 pp 21-23

[Article by O. A. Semenov, V. F. Frolov, I. D. Shchedrov, Yu. P. Orro and I. B. Kostyukov, All-Union Scientific-Research and Design-Technological Institute of the Pipe Industry]

[Abstract] A plan has now been developed for an automated continuous-flow line for the production of pipe 8-30 mm in diameter with wall thickness of 0.8-3 mm

and section length of up to 23 m from corrosion-resistant steel. The production technology includes hot rolling (Pilger method) with oil lubrication, preliminary laying in long loops, removal of lubricant with aqueous washing solutions, non-oxidizing heat treatment in purified hydrogen, straightening, grinding and polishing of the outer surface when necessary, combined nondestructive quality testing, final layout, treatment of ends and packaging. Individual elements of the technology could be introduced on existing equipment by slight reconstruction or on new equipment made according to the plans newly developed, but the best effects will be achieved by introducing the entire process planned.

UDC 669.14.018.8:621.771.23.016.3]:539.214

Plasticity Reserves of Cold-Rolled Corrosion-Resistant Ferritic Steels

18420051d Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian No 3, Jul-Sep 88 pp 27-28

[Article by N. A. Shulika, Zaporozhstal Metallurgical Combine]

[Abstract] A study was made of thin sheet cold rolled 08Kh18T1 and 08Kh18F2T1 steel, rolled at 25-80 percent deformation. The study established that the mechanical, plastic and technological properties depend largely on the degree of deformation during cold rolling. The results indicate that the best properties are produced in steels rolled with 68-71 percent deformation. This degree of deformation in combination with favorable chemical composition can result in up to 17 percent greater plasticity of thin sheet cold rolled corrosion resistant ferritic steels. References 3: all Russian.

UDC 621.791.75

Kinetics of Slow Breakup of Heat-Affected Zone in Welds Joining Low-Alloy High-Strength Steel

18420071 Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 4, Aug 88 (manuscript received 13 Jan 87) pp 101-107

[Article by V. V. Volkov, Physical Technical Problems of the North Institute, Yakutsk branch, Siberian Department, USSR Academy of Sciences, and V. Ye. Mikhaylov, Electric Welding Institute imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study of the heat-affected zone in welds joining 14Cr2MnMoB steel was made for the purpose of monitoring the kinetics of its slow breakup by cracking: from the inception of submicroscopic cracks through their growth to microscopic size and subsequent stable growth during plastic deformation with attendant hydrogen penetration. To their spontaneous propagation. Such a cracking, which follows formation of nonequilibrium structures in and around the welding seam with attendant segregation of accreted nonmetallic inclusions and hydrogen at grain boundaries and defect edges as well as thermoplastic deformation in regions of maximum temperature gradients and stress concentrations, was monitored by simulation of the heat-affected zone in welds joining small rectangular bars at their 2 mm wide and 8 mm long edges. Breakup was intentionally initiated by cutting 40-45 deg wide and 0.5 mm deep V-notches with tips rounded to a 0.1 mm radius as stress concentrators in the lateral surfaces. Welding was done with electric current so that the maximum temperature at a notch reached 1340-1360 deg C, in an argon atmosphere, with the cooling process characterized by a rate of 31-35 deg/s from 600 deg C to 500 deg C and 12-16 deg/s at the 300 deg C point. Two specimens were then hydrogenated to a 45 cm^3/kg H_2 level by polarization in aqueous 5 pct H_2SO_4 solution with hyposulfite and stored in liquid nitrogen. After polishing at -70 deg C and etching of their surfaces for micro-structural examination, they were tested under a constant load adjustable up to 1500 kg: one specimen for periods of time up to 10 min and one specimen for periods of time up to 51 min. References 8: 7 Russian, 1 Western.

UDC 669.184.244.66

Design of Converter Steelmaking Technology for Conservation of Materials

18420027a Moscow STAL in Russian No 8, Aug 88 pp 20-22

[Article by V. M. Zhuravlev, P. I. Yugov, V. S. Kolpakov and V. P. Mokrova, Central Scientific Research Institute of Ferrous Metallurgy and Cherepovets Metallurgical Combine]

[Abstract] A converter steelmaking technology has been designed which conserves pig iron and thus significantly reduces the cost of steel production. With only lime (95 pct CaO) added to the charge, the CO_2 content in the flue gas is 14 pct during a blow. The slag with a basicity of 3.0 contains 54.4 pct CaO, 18.1 pct SiO_2, 17.2 pct iron oxides and 7 pct metallic iron. In experimental blows of killed low-carbon steels (grades 10, 3, 2) and of 09Mn2Si alloy steel the consumption of pig iron and lime has been reduced by 8.6 kg/ton and 13.4 kg/ton respectively, while the yield of molten steel has been increased by 0.8 pct and the duration of one blow cycle has been shortened by 8.11 min. These indicators can be improved further by better preparation of the charge, a 0.9 pct increase of steel output with 38.2 kg/ton less pig iron and 21.5 kg/ton less lime being theoretically feasible.

UDC 669.18-147:621.771.22

Improving Quality of Graded Rolled Stock Made from Continuously Cast Cr15 Ball-Bearing Steel

18420027b Moscow STAL in Russian
No 8, Aug 88 pp 23-24

[Article by V. I. Listopad, V. M. Parshin, V. P. Slednev and V. F. Gubaydulin, Central Scientific Research Institute of Ferrous Metallurgy, Donetsk Metallurgical Plant, and Donetsk Polytechnic Institute]

[Abstract] A new technological process of continuous casting applicable to Cr15 ball-bearing steel is being developed which will eliminate axially concentrated liquidation and, with uniformly spread liquation, will ensure high quality of rolled stock made from castings of this steel. In the first experiment for this project the effect of various treatments during pouring and solidification of the melt, such as cooling or stirring the liquid, vibrating the solid at low frequency or ultrasonically, addition of rare-earth metals or of steel strips was studied. The detrimental effect of impurities was, for the purpose of this study, minimized by limiting the impurity content to 0.19 pct Cu, 0.02 pct P and 0.01 pct S. The melt at 1640-1660 deg C was deoxidized by addition of 0.02-0.03 pct Al, in the casting machine. The melt was poured into an intermediate ladle with an alumina lining, its temperature being held at 1100-1150 deg C and the temperature of the melt staying within 1510-1490 deg C. From here it was poured through a zirconium beaker with scavenging by argon jet and then through a graphite-corundum beaker to a crystallizer. The crystallizer cross-section was tapered downward by as much as 1.0-1.2 pct and pouring was done at a rate of 0.4-0.5 m/min, which prevented streakwise liquidation. After having been heated in a bizonal furnace without homogenization, 35 castings were rolled in a 950/900 mill. Each casting yielded two nondefective graded billets 115x115 mm^2 in cross-section and one with an axial-liquation zone. Following an evaluation of these billets and subsequent refinement of the process for optimum results, such rolled stock was produced in the 320/250 mill at the Serp i Molot plant with use of a preheating furnace and a accelerated-heating furnace. This stock is up to 50 pct more hardenable and has an up to 40 pct higher impact strength than rolled stock made from ingots produced by direct casting into molds after electroslag resmelting.

UDC 669.187.2

Increasing Intensity of Oxygen Blast During Smelting of Corrosion-Resistant Steel

18420027c Moscow STAL in Russian
No 8, Aug 88 pp 46-48

[Article by V. M. Shifrin, Dnepropetrovsk Metallurgical Institute]

[Abstract] As a basis for optimizing the blast intensity during the oxidation phase of smelting corrosion-resistant steel, an experimental study of carbon oxidation in the process and a statistical evaluation of the data have revealed how the rate of carbon oxidation and, thus, the necessary blast intensity depend on the principal process parameters. The oxygen utilization factor has been calculated for 20-ton and 50-ton electric-arc furnaces in accordance with the author's two semiempirical equations for the rate of chromium decarburization and chromium oxidation respectively. The results indicate that increasing the intensity of oxygen blast to 1.2-1.4 m^3/(ton.min) during the high-intensity stage and decreasing it to 0.7-0.5 m^3/(ton.min) during the final stage for 12Cr18Ni10Ti steel improves the process indicators. The optimum blast intensity does naturally depend on the grade of steel, particularly its chromium and carbon content, as well as on the technological characteristics of the apparatus.

UDC 621.771.237:669.014.29

Production of Rolled Steels with Guaranteed Mechanical Characteristics

18420027d Moscow STAL in Russian
No 8, Aug 88 pp 56-57

[Article by M. N. Sorokina and V. G. Poluboyarinova, Orsk-Khalilovo Metallurgical Combine]

[Abstract] A procedure for ensuring the required mechanical characteristics of hot-rolled low-carbon steels (high-strength killed St3) for sheet, strip, or channel-40 sections and hot-rolled low-alloy steels (09Mn2, 09Mn2Si, 14Mn2) for strip as well as for channel-40 or angle sections has been devised at the Orsk-Khalilovo Metallurgical Combine, each grade of steel being subdivided into normal-strength class-1 and high-strength class-2 with a 12-20 pct difference in strength between them. The procedure is based on chemical analysis of the steel composition and on statistical analysis of the key mechanical characteristics, the composition index for required characteristics depending on the thickness of the rolled stock.

UDC 621.771.07:621.892

Improving System of In-Process Lubrication for Rollers of Model-2500 Mill

18420027e Moscow STAL in Russian
No 8, Aug 88 pp 66-67

[Article by V. F. Pivovarov, N. P. Netesov, A. F. Kiliyevich, V. N. Girenko and N. L. Zaysanova, Magnitogorsk Metallurgical Combine and the Institute of Ferrous Metallurgy]

[Abstract] The existing system of in-process lubrication with water-cooling of the rollers in stands 4-11 of the model-2500 hot-rolling mill has lubricant fed on the exit side of the stands through an automatically controlled check valve. Lubricant is fed after a strip has entered a stand, a delay being necessary for a strip to be reliably gripped at its front end by roller not yet lubricated. The

lubricant feed is cut off when the tail end of a strip leaves the preceding stand so as to allow for burn-off of residual lubricant on the working surface of rollers. Cottonseed oil spent in equipment for hot-tinning of steel plate is now used as lubricant, 3-5 g/s per stand being its optimum feed rate for lengthening the life of the rollers by 20-25 pct without causing skidding. This system has already been improved by preventing lubricant feed during mechanical and electrical faults in the valve-solenoid set. It can be further improved by using as lubricant reconditioned spent emulsion for OM cutting fluid, the latter containing 81 pct I-20A mineral oil and 19 pct fatty additives. This lubricant is less efficient than cottonseed oil but its better technological characteristics ensuring a higher wear resistance of rollers. It should be fed simultaneously to three or four stands so as to ensure stable rolling without skidding of rollers and its efficiency can be increased by adding to it 5-15 pct spent cottonseed oil. References 1: Russian.

UDC 621.793.5:669.5]:621.778

Coating Low-Carbon Steel Wire With Zinc Alloys

18420027f Moscow STAL in Russian
No 8, Aug 88 pp 77-78

[Article by A. V. Trubitsyn, N. M. Mukhamedshina, M. I. Salykova and N. A. Valiullina, All-Union Scientific Research Metalware Institute]

[Abstract] An experimental study of several Zn-Al alloys with different fractions of aluminum and of additives (Si,Sn) as replacements for pure zinc for coating low-carbon steel wire for horticultural and other purposes was made at the All-Union Scientific Research Metalware Institute, its purpose being to develop a corrosion-resistant and plastic coating of smaller thickness, thus further economizing on scarce zinc with the additional advantage of weight reduction. Wires of four sizes for different applications were produced in 500 kg lots with experimental-industrial equipment: 1.7 mm diameter for clamping citrus trees, 2.0 mm diameter for banding fruit trees, 2.5 mm diameter for espaliers, and 2.5 mm diameter for overhead lines. These wires were coated and then tested for surface density of coating, for relevant mechanical characteristics, and for corrosion resistance in an NSm-CN salt-spray chamber with an aqueous 5 pct NaCl solution at a temperature of 35-40 deg C and 95 pct relative humidity inside. References 5: all Western.

Experience in Conversion of Electric-Arc Steelmaking Furnaces to Plasma Furnaces

18420026 Moscow METALLURG in Russian
No 8, Aug 88 pp 29-30

[Article by V. M. Kuznetsov, Chelyabinsk State All-Union Institute for the Design of Metallurgical Plants]

[Abstract] Three electric-arc steelmaking furnaces of the Chelyabinsk Metallurgical Combine have one after another been converted to plasma furnaces with ceramic crucibles. Experience in designing and implementing this conversion has revealed several problems, the two most serious being the much more restricted diversity of steel grades one plasma furnace can handle and the need for more controlled preparation of the charge. Other problems arise in connection with the much larger size of the electric power supply and its necessarily greater distance from the furnace, which calls for a larger busbar cross-section. Passing the busbars through a gallery on the roof of the furnace house is economically most expedient, an underground duct being more costly and complicated. The problem of smoke-proofing must be solved individually in each plant, no special equipment being needed in the opinion of some specialists. The most extensive experience in plasma steel-smelting technology with ceramic crucibles, in the design of plasma furnaces, and in industrial operation of such furnaces is available at the Central Scientific Research Institute of Ferrous Metallurgy, the Chelyabinsk State All-Union Institute for the Design of Metallurgical Plants, and the Chelyabinsk Metallurgical Combine respectively.

UDC 621.1.822.002.2:621.762

Bearing Parts From Powders

18420050 Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian
No 8, Aug 88 pp 25-26

[Article by B. Yu. Dorofeyev, All-Union Scientific Research and Design-Technological Institute of the Bearing Industry Scientific-Production Association]

[Abstract] Experiments have shown that nonporous powder chrome steel is equal in contact strength to ShKh15 cast bearing steel when made from powder components of the alloy or their master alloys or powders produced by spraying a melt or grinding chips of ShKh15 steel. The use of such powder materials can greatly reduce the consumption of expensive bearing steels. Experiments have further shown that the use of hot stamping of powder blanks can increase the maximum usable powder particle size to 1200 μm, while significantly improving productivity and decreasing the cost of power to grind chip to the required size and correspondingly reducing the content of oxides in the powder produced. Various hot compacting schemes allow the production of materials with good physical-mechanical and usage properties from powders not suitable for traditional cold pressing and sintering.

Improvement in Production Technology for Continuous-Cast Slabs of Low-Alloy Steel for Rolling of Thick Sheets

18420043 Moscow METALLURG in Russian
No 7, Jul 88 pp 37-38

[Article by G. Z. Zaslavskiy, B. N. Gogolev, M. M. Poner, V. P. Solntsev and G. Ye. Geynts, Nizhniy Tagil Metallurgical Combine]

[Abstract] At the authors' combine, metal for production of thick sheets is produced by continuous casting and

deoxidized using silicozirconium and a titanium-containing calcium master alloy, allowing deep deoxidation of the metal and producing good impact toughness of the rolled sheets at low temperatures. This permits a decrease in the quantity of aluminum used for deoxidation, reducing the quantity of aluminum in the steel and improving the quality of the surfaces of the sheets. The optimum consumption of deoxidant is that which yields a residual aluminum content of 0.011-0.015 percent, yielding good surface quality and satisfactory impact toughness.

UDC 669.187.56:621.772.001.5

Manufacture of High Pressure Vessel Blanks of Transition Class Steels by Electroslag Casting

18420066a Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian
No 3, Jul-Sep 88 (manuscript received 29 Oct 85)
pp 15-19

[Article by L. Ya. Gluskin, V. V. Zhitkov and V. L. Mizetskiy]

[Abstract] Experiments were performed on the manufacturing of models of high-pressure vessels by electroslag casting under laboratory and industrial conditions using type 05Kh13N6M2 and 05Kh10N5M3 transition-class steels. Heat treatment conditions and properties were studied. Mechanical testing indicated that the properties of the cast electric-slag metal in the longitudinal and transverse directions following heat treatment were similar to the properties of deformed metal. Higher impact toughness was achieved in steel remelted under type ANF-6 flux. Properties were virtually isotropic. The microstructure was almost the same as that of deformed metal. The method produces products with smooth surfaces, homogeneous structure and no internal defects. Heat treatment consisted of hardening from 1050°C in water with tempering at 550-700°C. Mechanical properties of specimens cut from model high-pressure vessels were found to be at the same level as the properties of deformed metal, indicating good strength characteristics of the metal throughout its cross section. References 5: all Russian.

UDC 669.187.56:621.74.004.12.001.5

Quality of Tee-Joint Blanks Produced by Centrifugal Electroslag Casting

18420066b Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian
No 3, Jul-Sep 88 (manuscript received 4 Mar 88)
pp 23-26

[Article by V. P. Lukyanets, G. S. Marinskiy, V. L. Shevtsov, A. V. Chernets and M. L. Zhadkevich, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] Results are presented from a comprehensive study of the quality of 15KhSND steel tee-joint blanks, designed for operation in the Far North, at 25 MPa. The raw material used for electroslag centrifugal casting was 20-30 mm thick substandard sheet scrap. Studies indicated the high quality of the blanks, with smooth surfaces requiring no additional mechanical working, allowing the method to be recommended for the production of both high pressure pipe connecting elements and other machine parts such as stop valves. Reference 1: Russian.

UDC 669.187.56:621.774.1.001.5

Study of Properties of 17G1S-U Reinforced Quasimonolithic Pipe Steel at Negative Temperatures

18420066c Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian
No 3, Jul-Sep 88 (manuscript received 4 Mar 88)
pp 40-44

[Article by V. Ya. Sayenko, L. B. Medovar, N. M. Shelestyuk, V. I. Us, N. B. Pivovarskiy and S. A. Us, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] In many cases, reinforced quasimonolithic steel can be used in place of electroslag remelted steel. With its organized multilayer internal structure, this steel has the properties of multilayer metallic materials under dynamic loading and at low temperatures and the properties of ordinary metal materials under static loading. Due to the bonding between layers, the steel looks like ordinary monolithic metal, does not separate into layers when bent, rolled, stamped or mechanically worked, and structures welded of the material have good rigidity and strength. This article discusses the properties of type 17G1S-U reinforced quasimonolithic steel at below-freezing temperatures and its resistance to brittle fracture as determined by the DWTT method. These tests indicated that the critical brittleness temperature of the steel is below the design operating temperature of Northern gas pipelines, -15°C. The new steel, type 17G1S-U AKM, has increased resistance to brittle fracture at below-freezing temperatures in comparison to ordinary monolithic steel of the same composition. References 5: all Russian.

Alloys Institute Develops Materials For Aircraft-Engine Parts

18420105 Moscow IZVESTIYA in English 5 Dec 88 p 1

[Extract] Development of materials for producing aircraft-engine parts capable of operating reliably at high temperatures and under heavy stresses is a difficult technical problem. Such materials have been obtained at the All-Union Institute of Light Alloys (VILS). They are protected by dozens of certificates of invention.

Complex alloys are obtained with the aid of unique equipment at VILS.

One of the institute's latest innovations is a special process for producing parts of engines for the modern IL-96 and TU-204 passenger airliners. A group of developers of this highly effective process has been awarded the State Prize.

(The photograph shows Candidate of Technical Sciences I. Kononov and doctors of technical sciences G. Garibov and V. Khodkin, State Prize laureates, preparing an experiment with high-vacuum heat treatment of parts.)

UDC 669.295:620.178.311.868

Nature of Influence of Isomorphous β-Stabilizing Elements on Vulnerability of Titanium α-Alloys to Corrosion Cracking in Aqueous Chloride Solutions

18420062g Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 88 pp 48-51

[Article by L. A. Ivanova, A. I. Igolkin and Yu. D. Khesin]

[Abstract] This article is a generalization of the literature on the influence of β-stabilizers on the sensitivity of titanium alloys to corrosion cracking in chloride solutions; it examines the nature of this phenomenon on the basis of additional experiments. A table lists the chemical composition of the alloys investigated. Vanadium was used as the β-stabilizing element and chromium and iron were used as the eutectoid-forming elements. Ingots weighing 10 kg were rolled into rods with a diameter of 20 mm at 920-980°C, depending on the temperature of the polymorphous transformation. The research revealed that a decrease in the vulnerability of titanium alloys to corrosion cracking in chloride solutions with the introduction of β-stabilizers is associated with suppression of the precipitation of the α_2 phase and is dependent on the supersaturation of the α-solid solution by β-stabilizers. The concentration of the α-phase and,accordingly, the sensitivity to corrosion cracking, are determined by the conditions for hot deformation and heat treatment of the semifinished products. The effectiveness of alloying is ensured by restriction of heating time in the high-temperature part of the (α + β)-region. Annealing or plastic deformation in the β-region result in a maximum alloying effectiveness. References 11: 3 Russian, 8 Western.

UDC 669.285:621.778

Wire Produced From VR-20 Tungsten Alloy Bars by Rolling and Dependence of Its Quality on Rolling Process Parameters

18420034f Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 19 Feb 87) pp 102-107

[Article by Ye. V. Ushakov and Ye. K. Drobysheva, Moscow]

[Abstract] Producing wire from bars of a refractory material by hot rolling with edging of the bars into rods and subsequent rotary swaging of the rods and final drawing of wire is analyzed for the purpose of optimizing the rolling process on the basis of a factorial experiment. The experiment was designed for VR-20 tungsten alloy, bars of this material (density 17.2 g/cm^3) 8.5x8.5 mm^2 in cross-section to be hot rolled into rods 8 mm in diameter (first pass) and then into rods 6 mm in diameter (second pass) for subsequent swaging to a 2.75 mm diameter followed by drawing into wire 1.45 mm in diameter. Each rolling pass inside a tubular furnace, in a hydrogen atmosphere, was followed by recrystallization annealing in the same atmosphere. The experiment was a 6-factorial 3-level one involving six independent process variables set successively at three levels (upper-nominal-lower) and five product quality indicators. The process variables were: temperatures of bars prior to first pass and of rods prior to second pass (1350-1300-1250 deg C), heating time prior to first pass and prior to second pass (140-130-100 s), annealing temperature after first pass and after second pass (2200-2100-2000 deg C). Selected as the principal optimizable product quality indicator was the relative parting length in wire (to be minimum), another two being the numbers of cracks in 8 mm rods and in 6 mm rods (to be minimum), the density of material in 8 mm rods being the fourth, and the percentage yield of acceptable wire (to be maximum) being the fifth. The experiment had been reduced to the minimum number of tests, namely 8 according to the 2^{6-3}-factorial plan for pairwise interplay of variables with three supplemental ones for parting in wire and four special ones for higher-density material (18.3-18.7 g/cm^3). The parting length was measured by the eddy-current method with a VD-20P instrument, the density of bar material was measured radiographically, the density of rod material was measured by hydrostatic weighing, and the number of surface cracks was estimated visually. Miscostructural examination under a transmission electron microscope with x30,000 magnification has confirmed the results of regression analysis of the experimental data, namely that a lower temperature prior to the first pass increases the resistance, the temperature prior to the second pass being a less significant factor but also to be preferably lowered, and that bars of material with a

higher density yield wire of higher quality with higher resistance to parting even despite wide temperature oscillations during the rolling process. References 7: all Russian.

UDC 669.294-172:548.735.6

Structurization of Tantalum Single Crystals During Rolling

18420034g Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 13 Apr 87) pp 108-112

[Article by G. S. Burkhanov, V. P. Gubchevskiy, D. M. Zlatoustovskiy, A. N. Mironicheva, S. V. Milnikova, and Ye. V. Ottenberg, Moscow and Magnitogorsk]

[Abstract] A study of tantalum was made concerning structurization of its single crystals during deformation by knurling, tantalum being one of the metals with a b.c.c. crystal lattice. Single crystals, rods 10 mm in diameter with <011>, <111>, and <631> orientations grown by two-pass electron-beam zone refining, were rolled parallel to the axis and thus along the respective orientations. Their structure was analyzed by the method of pole figures in a DRON-3.0 x-ray diffractometer with a MoK_{alpha}-radiation source and with a bent LiF crystal serving as monochromator. Transverse sections as well as sections normal to the direction of rolling and sections normal to the plane of roll joints were microphotographed. A single crystal with initial <011> 211 orientation could be rolled to 90 pct deformation, fragmentation occurring during up to 30 pct deformation and only partial reorientation of fragments occurring during 30-90 pct deformation. A single crystal with initial 112 <111> orientation could be rolled to 90 pct deformation, reorientation of fragments beginning already at 6.5 pct deformation and becoming almost complete (80 pct of all fragments) during 70-80 pct deformation before gradually ceasing with a stable new configuration reached during 80-90 pct deformation. A single crystal with initial 013 <631> orientation could be rolled to 90 pct deformation, fragmentation occurring already at 8 pct deformation and the orientation of fragments blurring at 16 pct prior to partial reorientation (30 pct of all fragments) into a stable new configuration during 40-90 pct deformation. Evidently all slip planes are involved in deformation of Ta single crystals. References 10: 3 Russian, 7 Western (2 in Russian translation).

UDC 621.785.7:669.715

Dependence of Structure and Properties of Aluminum Alloys Hardenable by Heat Treatment on Drawing Process Parameters

18420034h Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 27 May 87) pp 113-117

[Article by M. Ye. Smagorinskiy and M. V. Roze, Leningrad]

[Abstract] An experimental study of quenched and then drawn AVYe aluminum alloy (0.6 pct Si, 0.6 pct Mg, 0.45 pct Fe) for electrical conductors was made concerning the effect of combined low-temperature heat treatment and mechanical forming by drawing. This alloy is hardenable by heat treatment and for this study was quenched from 530 deg C. Wires were drawn from 9 mm to 5 mm diameter in 10 passes, with heating to various temperatures (160,180,200 deg C) in oil and holding for various lengths of time (10,30,90,300 s) at each temperature before cooling back to 20 deg C in water between passes. Some wires were only aged at 165 deg C for 10 h after the last pass without heating and cooling between passes. Specimens of each differently treated wire were subsequently tested electrically for resistivity as well as mechanically for tensile strength and percentage elongation. They were also examined under an electron microscope with x50,000 magnification for differences in their microstructure after single and repetitive heat treatment during mechanical forming respectively. The results indicate that more and better combinations of mechanical and electrical characteristics are attainable by repetitive heat treatment with regulation of its parameters during mechanical forming of aluminum alloys. References 4: all Russian.

UDC 669.15'24'74-194:620.17

Mechanical Properties of Fe-C-Mn-Ni-Cr-Si-Mo Alloys

18420034m Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 4 Dec 86)) pp 155-158

[Article by Yu. M. Balychev, F. K. Tkachenko, and M. N. Shanin, Zhdanov]

[Abstract] A factorial experiment was designed and performed for the Fe-C-Mn-Ni-Cr-Si-Mo system of alloys, its purpose being to control the mechanical properties as functions of the composition. Ten test alloys were considered, all with the same 0.5-0.7 pct Cr, 0.7-0.0 pct Si, 0.3-0.5 pct Mo content, also with 0.03-0.05 pct Ti, 0.02-0.05 pct Al, and not more than 0.02 pct S, 0.02 pct P, and 0.01 pct N_2. The system was treated as a ternary one and the fractions of the three components X_1, X_2, X_3 (1. Fe with 0.05 pct C and 6.0 pct Mn; 2. Fe with 0.05 pct C and 4.0 pct Ni; 3. Fe with 0.30 pct C and 4.0 pct Ni) constituted the set of independent variables. The product quality indicators considered were seven mechanical properties: Y_1 - tensile strength; Y_2 - 0.2 pct yield strength; Y_3 - percentage elongation; Y_4 - percentage reduction; Y_5, Y_6, Y_7 - KCV impact numbers at 20 deg C, -10 deg C and -70 deg C respectively. Standard mechanical tests were supplemented with dilatometric tests and x-ray structural examination of the alloys for a determination of their Ac_1 and Ac_3 temperatures. An evaluation of the data on a simplex grid has yielded a set of seven regression equations, one for each mechanical property Y as a function of the alloy composition in the form of an incomplete third-degree polynomial in X_1, X_2, X_3 (only X_1, X_2, X_3, X_1X_2, X_1X_3, X_2X_3, $X_1X_2X_3$ terms) on the right-hand side. The results of numerical

calculations are presented graphically, isolines of each mechanical property being plotted on the ternary constitution diagram. References 6: 3 Russian, 3 Western (1 in Russian translation).

UDC 546.281.631+669.018

Characteristics of Ternary Systems Sc-Mo-Si and Sc-Mo-Ge at 1070 K Temperature

18420034o Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 2 Mar 87) pp 189-192

[Article by B. Ya. Kotur and O. I. Bodak, Lvov]

[Abstract] Constitution diagrams of the two ternary systems Sc-Mo-Si and Sc-Mo-Ge at the 1070 K temperature have been constructed on the basis of available data on four compounds in each of the four binary systems Mo-Si, Mo-Ge, Sc-Mo, and Sc-Ge. Specimens of alloys were produced by mixing Sc and Mo powder compacts with polycrystalline Si or Ge in an electric-arc furnace with a tungsten electrode on a water-cooled copper hearth in an atmosphere of purified argon, all components being 0.999 pct pure and the mass of an alloy specimen not differing by more than 0.01 pct from the combined mass of all its components. The specimens were homogenized by annealing at 1060-1080 K for 740-1000 h under vacuum, then quenched with their quartz containers in cold water. Phase analysis was based on x-ray microstructural examination in an RKD-57.3 camera with a CrK_{alpha}-radiation source and partly also on metallographical examination under an MIM-8 optical microscope. Crystallographical examination was done in a DRON-3.0 x-ray diffractometer with a CuK_{alpha}-radiation source, single crystals being photographed with an RKV-86 camera and an RGNS-2 camera. Quantitative evaluation of the data was aided by an SM-4 computer. The results indicate formation of only one compound in each system at 1070 K, namely $Sc_2Mo_3Si_4$ and $Sc_{2\ plus\ x}Mo_{3\ minus\ x}Ge_4$ (x ranging from 0 to 2) respectively, also of substitutional solid solutions $Sc_{5-x}Mo_xSi_3$ (x ranging from 0 to 2) and $Sc_{5-x}Mo_xGe_3$ (x ranging from 0 to 0.8). References 10: 8 Russian, 2 Western (1 in Russian translation).

UDC 669.295:539.431.015

Application of Fatigue Fracture Similarity Theory to PT3V Titanium Alloy With Various Structures

18420049d Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 8 Dec 87) pp 77-81

[Article by O. S. Kalakhan, A. I. Lebedeva and N. A. Prevarskaya, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] A study is presented of the influence of the structure of PT3V alloy, stress concentration, the scale factor and the type of loading on its fatigue fracture resistance. Smooth specimens and specimens with a stress concentrator were used to study fatigue resistance in bending with rotation at 3000 cycles per minute. The globular type structure was found to be more fatigue resistant. The plate-like structure was more sensitive to changes in structural parameters than the globular structure. Increasing the α-particle size in the globular structure by a factor of 2-3 has virtually no influence on endurance, whereas increasing the parameters of the plate structure decreases the fatigue strength of the alloy, particularly when β grains are present with the plate-like α phase. Stress concentrators did not reveal any advantages of the plate-like structure. The greatest endurance was still that of the globular structure alloy. References 2: both Russian.

UDC 620.194

Corrosion-Mechanical Fracture Resistance of Al-Zn-Mg Alloy Panels

18420049g Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 1 Sep 87) pp 115-116

[Article by A. V. Kobzaruk, A. V. Bakulin and L. N. Nelzin, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] The purpose of this work was to study the influence of hardening and aging conditions on the corrosion-mechanical properties of pressed ribbed panels of type V92Ts aluminum alloy in sea water. Specimens were cut from the section between ribs of panels in the transverse direction. Corrosion cracking and low-cycle fatigue resistance were studied on specimens deformed by bending. No tendency to corrosion cracking nor delaminating corrosion was observed in any of the specimens except those artificially aged by heating. The durability of ribbed specimens in fatigue testing was 3-5 times less than nonribbed specimens, with several cracks developing simultaneously. In air, no such difference was observed. The reduced corrosion-mechanical failure resistance of the ribbed surface is observed both after zone and after phase aging with identical alloy strength level. Hardening in hot water with subsequent artificial aging can significantly reduce the time required to achieve good strength properties without decreasing corrosion-mechanical fracture resistance. Low-cycle fatigue testing is superior to standard corrosion crack testing in its ability to reveal corrosion-mechanical fracture sensitivity of ribbed panel surfaces. References 2: both Russian.

UDC 621.785.4

Crack Resistance of Rotor Cr-Ni-Mo-V Steel With Bainite Structure

18420055a Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 2-6

[Article by Yu. A. Boychenko, A. V. Sosnin, A. M. Shkatova, N. A. Shokov and L. G. Kulikova; Elektrosila Production Association; All-Union Electrical Machine Building Scientific Research Institute]

[Abstract] Results are presented from an estimate of a

complex of static and cyclical crack resistance characteristics through the cross section of three full-scale rotor forgings of type 35 KhN3MFA and type 25 KhN3MFA steel made by different technologies. Static crack resistance was determined at normal temperature in air by concentrated bend testing of 25 mm thick prismatic specimens with a crack on one side and lateral notches. Fracture toughness was determined by the force and energy approaches. Cyclical crack resistance was tested with a symmetrical load at 25 Hz in air and with electrolytic hydrogen saturation using 6 mm thick flat beam specimens. Metallographic analysis indicated that all surface zones had fine-grain structure, while the size of the initial austenite grains increased as the center of the forgings was approached. The high-tempered bainite structure of the forgings had a variable influence on the fracture toughness and stress intensity factor of the large forgings. The fracture toughness is significantly less in steel of technical purity deoxidized with silicon with high-tempered upper bainite structure than in steel with high-tempered lower bainite structure. The high-tempered upper bainite structure improves fatigue resistance. Deoxidation with carbon in a vacuum and combined refining to remove phosphorus and sulfur result in significantly lower brittleness and a larger initial austenite grain size. References 7: all Russian.

UDC 621.74:669.55

High-Aluminum Zinc Alloys

18420024c Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 88 p 9

[Article by T. N. Lipchin, candidate of technical sciences, V. N. Yanchuk, candidate of technical sciences, V. N. Berdnik, engineer, G. V. Lepekhin, engineer, and Ye. V. Kryukova, engineer]

[Abstract] A new high-strength low-friction Zn-Al alloy TsAM48-5 with 48 percent A1 has been developed by the Perm Polytechnic Institute and the All-Union Scientific Research Institute for Automotive Materials for pressure casting and chill casting. Its mechanical properties (hardness, strength, plasticity) before and after heat treatment (quenching, annealing, aging) and its corrosion resistance were measured on experimental specimens 6 min in gage diameter for chill-cast specimens and rectangular bars 45 mm long and 3x20 mm^2 in cross-section for pressure-cast specimens. Its casting characteristics were also measured: fluidity on a rod, shrinkage on cylinders of 100 mm gage length, and hot-shortness on an I. I. Novikov specimen. Density of the material was measured by hydrostatic weighing. Corrosion measurements were made by the accelerated method (7 days) in aqueous 3 percent NaCl plus 1 pct HCl solution. The range of melting temperatures was established on the basis of differential thermal analysis with a derivatograph. considering that Zn-A1 alloys are usually cast into molds made of 4Cr5MoVSi steel, the resistance of this mold material to the electrochemical efforts of contact with Zn and A1 was also measured. A comparison with similarly evaluated domestic alloys TsAM4-1 (4 pct A1), TsAM10-2 (10 percent A1) and foreign alloys equivalent to TsAM27-2 (27 percent A1), TsAM30-5 (30 percent A1) indicates that this new high-A1 alloy excels the TsAM30-5 alloy is strength after aging and the TaAM10-2 alloy in heat resistance at 100-150 deg C.

UDC 621.74:669.715

Effect of Several Elements in Cast Aluminum Alloys Modified by Addition of Na and Sr on Its Structure and Surface Tension

18420024d Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 88 p 10

[Article by A. V. Kurdyumov, doctor of technical sciences, S. V. Inkin, candidate of technical sciences, R. Bekher, engineer, and I. Bekher, engineer]

[Abstract] An experimental study of AL4 cast aluminum alloys either modified by the addition of 0.1 pct Na or 0.15 pct Sr or not, was made for the purpose of determining the effect of several other elements on the structure of these alloys and their surface tension during casting. Each alloy was smelted in an induction furnace with a graphite crucible, heated to 800 deg C, and cast into molds. The ingots weighed 100-150 g each at 750 deg C. At the appropriate temperature of the melt P, Ga, Cd, Sn, Sb and Bi were added, each to a different ingot in amounts varied from 0.05 percent to 0.2 percent. The effect on the microstructure was gauged by the length of crystals of eutectic Si. The surface tension was measured on the basis of maximum straining force at the alloy-flux. A185 primary aluminum, Mg90 primary magnesium, and 90 A1 - 10 Mn alloy were similarly evaluated for comparison. The results indicate that only Na increases the dispersity of Si crystals, while Ga, Sn, Sb, Bi in the amounts of 0.05-0.1 percent act as demodifiers coarsening the structure. Therefore, only modification by addition of Sr will ensure stability of the alloy structure containing Ga, Sn, Cd and Bi impurities. References 2: both Russian.

UDC 669.73

Structure of Copper Films Deposited on Porous Substrates by Magnetron Sputtering

18420028e Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul-Aug 88 (manuscript received 30 Dec 87) pp 98-101

[Article by O. S. Serebryannikova, V. A. Nesmeyanov, S. V. Shokol and V. M. Gryaznov, Moscow]

[Abstract] An experimental study of Cu films deposited on porous substrates by magnetron sputtering was made for the purpose of establishing the conditions most favorable to formation of an open film structure with separately growing columnar grains. A magnetron with argon as working gas under a pressure of 2.7 Pa was used

for deposition of 0.020-0.030 mm thick Cu films at a rate of 0.0015 mm/min on porous Ni and stainless steel substrates, the initial temperature of the substrates being 3 deg C ($0.22T_m$; T_m,K- melting point of copper). In the process the Ni substrates heated up to $0.32T_m$ (127 deg C) and the stainless steel substrates heated up to $0.27T_m$ (66 deg C). The stability of the film structure was tested by annealing under a vacuum of 0.2 mPa at 457 deg C ($0.58T_m$) for 1 h and at 757 deg C ($0.82T_m$) for 30 min. The structures were compared with those produced on substrates at an initial temperature of 457 deg C and found to be open, also after high-temperature annealing. This stability indicates that low substrate temperature and high argon pressure during film deposition inhibit volume diffusion so that all detectable structural transformations during subsequent annealing are associated with interparticle condensing recrystallization. References 4: 2 Russian, 2 Western.

UDC 669.863'73:538.665

Magnetocaloric Effect in Single Crystals of Terbium and Its Alloys With Gadolinium
18420040a Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 1, Jul 88 (manuscript received 8 Jan 87) pp 86-94

[Article by S. A. Nikitin, A. M. Tishin and S. V. Redko, Moscow State University imeni M. V. Lomonosov]

[Abstract] A study is presented of the magnetocaloric effect in single crystals of terbium and its alloys with gadolinium. Measurements were performed at 20-300 K in strong magnetic fields with induction up to B=6 Tl. Single crystal specimens of terbium and Tb_xGd_{1-x} were studied, where x=0.7, 0.4 and 0.2. The magnetocaloric effect near the Curie point is as great as 7-10 K in the strong fields used in this study. An equation is derived for computation of the theoretical value of the magnetocaloric effect which agrees satisfactorily with the experimental data (error 15-20 percent). References 16: 9 Russian, 7 Western.

UDC 54-185:(669.28+669.293):537.312.62

Superconductivity and Structure of Niobium and Molybdenum-Based Materials Deformed Under Pressure
18420040b Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 1, Jul 88 (manuscript received 27 Feb 87) pp 112-118

[Article by A. Ye. Karkin, V. P. Pilyugin, V. I. Voronin, R. I. Kuznetsov, B. N. Goshchitskiy and G. G. Taluts, Metal Physics Institute, Urals Department, USSR Academy of Sciences]

[Abstract] The superconducting properties, resistivity and structure of two-component mixtures based on niobium and molybdenum are studied after rolling and/or shear under pressure. Niobium mixtures with Cu, Ni, Zr and Y and molybdenum mixtures with Ni, B, Si, S, Ge, Se, Sn, Te, Rb and Bi are studied. Mechanical working decreases the critical temperature while residual resistivity and the ratio of residual resistivity to resistance at 295 K increase. Deformation produces a finely dispersed structure of strongly distorted particles of the individual components, decreasing the electron free path length and decreasing or increasing critical temperature in niobium and molybdenum systems, respectively. The second component in all the systems studied creates a greater concentration of defects scattering electrons. These may be substitution defects in disordered or amorphous alloys or various types of defects in pure metals. In the latter case the presence of the second component permits creation and stabilization of a relatively large number of defects, leading to strongly distorted lattices. References 20: 6 Russian, 14 Western.

UDC 669.2/.8:541.15

Possibility of Using Radiation-Chemical Technology in Nonferrous Metallurgy
18420058a Moscow TSVETNYYE METALLY in Russian No 9, Sep 88 pp 24-26

[Article by V. D. Nagibin, V. F. Denisov, A. P. Shvedchikov and A. N. Yermakov]

[Abstract] The appearance of high-power electron accelerators has resulted in a transition of radiation-chemical technology from the production of materials with unique and improved properties to the saving of natural resources and electric power and the solution of problems of environmental protection. Western experience in using radiation-chemical technology to remove SO_2 and NO_x from coal-burning power plant exhaust gases is outlined. In the USSR a process is now being studied involving directing a beam of accelerated electrons on a gas stream, causing ionization of molecules and their decomposition, forming charged molecular ions, atoms and radical, producing sulfuric acid from a gas stream containing sulfur dioxide and water vapor. Thermal-radiation synthesis of hydrogen and carbon monoxide, developed at the Chemical Physics Institute, USSR Academy of Sciences, can be broadly used in nonferrous metallurgy. Radiation-chemical synthesis of portland clinker with excellent strength characteristics has been demonstrated using 1.4 MeV, 100 kW accelerators. The technology should be effective in the manufacture of alumina. References 10: 8 Russian, 2 Western.

UDC 669.33

One-Stage Production of Crude Copper
18420058b Moscow TSVETNYYE METALLY in Russian No 9, Sep 88 pp 47-49

[Article by A. P. Snurnikov and S. N. Makarov]

[Abstract] The possibility is analyzed of producing copper in a single stage by processing of copper concentrate using two technologies presently in use in world practice:

smelting in the suspended state and smelting in a melt. The technology for producing copper by the first method has been developed abroad using raw materials containing 2-3 percent Fe, 20-65 percent Cu and 8-20 percent S. However, single-stage production by this method on an industrial scale has not yet been achieved. Smelting in a melt is more promising, and has been achieved by Mitsubishi and the Swedish Renshar company, processing primarily secondary raw materials. More detailed study of this foreign experience is required to determine whether domestic developments can eliminate the significant remaining difficulties. References 4: 1 Russian, 3 Western.

UDC 669.018.6

Shape Memory Effect in Copper Alloys at Fixed Temperatures

18420058c Moscow TSVETNYYE METALLY in Russian No 9, Sep 88 pp 85-87

[Article by V. K. Larin]

[Abstract] Proper selection of the type and composition of shape memory alloy, development of the technology for its production and processing require precise knowledge of the temperature conditions of achievement of shape memory in a specific product and determination of methods and means assuring observation of these conditions in a finished product. The first link in the chain of shape memory temperature control is determination of the charge composition required to manufacture the desired alloy. In Cu-Al-Mn alloys, increasing the aluminum content by 0.1 percent decreases the shape memory temperature by an average of 15°. Other elements have a still stronger influence on the effective temperature. The shape memory temperature is best determined by direct observation of specimens deformed when cool and warmed to the shape memory temperature. Pressure working of metals can also change the shape memory temperature, requiring its determination after all finishing operations are completed. References 5: 2 Russian, 3 Western.

UDC 621.762

Use of Powder Metallurgy Methods To Process Aluminum Alloy Wastes

18420058d Moscow TSVETNYYE METALLY in Russian No 9, Sep 88 pp 91-93

[Article by A. M. Serov, B. S. Mitin and V. A. Vasilyev]

[Abstract] A technological plan has been developed for processing of aluminum alloy wastes, including production of an alloy powder by rapid cooling of a sprayed melt on a spinning metal disk, pressing of blanks, liquid-phase sintering, calibration of blanks and forging of finished parts, cold or hot. Advantages of the new technology over existing powder technologies include the use of powders of alloys of standard chemical composition, low powder cost, no requirement for mixing operations, the possibility of sintering blanks in air, and no rigid requirements for sintering temperature accuracy. The new technology can achieve a savings of 1500-2000 rubles per ton of finished product, primarily by decreasing the metal cost. The Moscow Aviation Technological Institute has developed an installation for processing of wastes using this technology, which is now in use at machine-building enterprises. References 3: all Russian.

UDC 620.178.3

Quantitative Estimation of Fatigue Fracture Characteristics of Titanium Alloy Parts

18420038 Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 54 No 8, Aug 88 (manuscript received 16 Jan 87) pp 86-90

[Article by L. V. Limar and L. R. Botvina]

[Abstract] A method is presented for quantitative estimation of the fatigue fracture characteristics of titanium alloy parts based on fractographic and metallographic data. The method is based on accounting for the stages in the process of fatigue crack development, resulting from the plate-like microstructure and the alteration of fracture micromechanisms occurring with transitional stress intensity coefficient values, determining the shape of the fatigue fracture kinetic diagram in VT3-1 alloy. Further studies established that as a fatigue crack develops, there is not only a change in microscopic fracture mechanisms, but also a change in the form of the stress state at the tip of the crack from a flat deformed to a flat stress state, controlled by the size of the zone of plastic deformation at the tip of the crack, which is a function of the stress intensity factor, yield point of the material and stress state type under which fracture occurs. The solution of the problem is reduced to the determination of a series of crack depth values at which the stress intensity factor reaches transition values at the boundaries between areas on the fracture surface where the fracture micromechanism changes, followed by computation of the amplitude of the nominal stress causing fatigue fracture of the titanium alloy part with plate-like microstructure. References 5: 4 Russian, 1 Western.

UDC 669.245:669.111.35

Carbide Transformations in Nickel γ/γ' Alloy Upon Long-Term Aging

18420069b Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 2, Aug 88 (manuscript received 23 Dec 86; in final form 25 Feb 87) pp 313-317

[Article by A. A. Kopylov, V. V. Bogayevskiy, B. K. Pisarev, V. P. Lesnikov, V. A. Kopylova and V. V. Poleva, Urals Polytechnical Institute imeni S. M. Kirov]

[Abstract] A study is made of the carbide reactions occurring upon long-term aging in Ni-Cr alloys hardened with the γ' phase, and their influence on the residual

properties of the alloy. Studies were performed on specimens subjected to double hardening and aging up to 6000 hours at 850-900°C. The major carbide transformation was found to be segregation of $M_{23}C_6$ occurring in several stages and accompanied by the formation of microscopic pores. Five stages of aging were observed. In the early stages, carbide transformations have practically no influence on the residual properties of the material at temperatures above the equicohesive temperature. Following generation of pores at 2500-3500 hours (850°C), strength and ductility drop sharply. References 6: 4 Russian, 2 Western (1 in Russian translation).

UDC 669.295:620.182/.186

Structure and Properties of V2 Compounds of Titanium. I. Premartensitic Phenomena

18420069e Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian
Vol 66 No 2, Aug 88 (manuscript received 21 Jan 87; in final form 17 Apr 87) pp 350-358

[Article by V. G. Pushin, V. N. Khachin, V. V. Kondratyev, S. A. Muslov, S. P. Pavlova, deceased, and L. I. Yurchenko; Metal Physics Institute, Urals Department, USSR Academy of Sciences; Siberian Physical Technical Institute]

[Abstract] A systematic and comprehensive study is performed of the pretransition phenomena in V2 compounds Ti-Ni, Ti-Ni-Fe, Ti-Ni-Cu, in which all types of structural transformations possible in V2 titanium compounds occur. Bragg reflection x-ray diffractometry, diffusion scattering of x-rays and electrons and transmission electron microscopy are used to study a number of unusual diffraction effects, including a decrease in intensity and spreading of Bragg reflections, an increase in diffusion scattering as the martensite transformation point is approached, and contrast changes indicating the deformation origin of some effects. The anomalous behavior of resistivity, internal friction and many other physical properties in the premartensite state can be explained by considering the singular substructures formed in the premartensite state. There is a genetic relationship among premartensite states and martensite transformations in V2 titanium alloys. References 20: 14 Russian, 6 Western.

UDC 669.295:620.182/.186

Structure and Properties of V2 Titanium Compounds. II. Premartensite Instability of BCC (V2) Lattice

18420069f Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian
Vol 66 No 2, Aug 88 (manuscript received 27 Jan 87) pp 359-369

[Article by V. V. Kondratyev, S. A. Muslov, V. G. Pushin and V. N. Khachin; Metal Physics Institute, Urals Department, USSR Academy of Sciences; Siberian Physical Technical Institute]

[Abstract] Previous studies in this series have presented a detailed investigation of the structure of the premartensite state of V2 titanium alloys in the stage of formation of close-order displacement and intermediate shear structures and its influence on subsequent martensite transformations. This article analyzes the stability of the BCC (V2) crystalline lattice with respect to homogeneous distortions and short static waves. It is shown that the variety of pretransition structures and homogeneous nature of their formation can be explained by the singular elastic properties of these alloys, plus great softening of the phonon branch of transverse lattice oscillations. A computation example is appended. References 21: 9 Russian, 12 Western (2 in Russian translation).

UDC 669.295'788:539.216.2:548.313

Stabilization of Titanium Hydride FCC Structure by Oxygen in Condensed Films

18420069g Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian
Vol 66 No 2, Aug 88 (manuscript received 25 Nov 86; in final form 23 Feb 87) pp 411-413

[Article by Z. Z. Zyman and V. I. Glushko, Kharkov State University imeni A. M. Gorkiy]

[Abstract] A study is made of the influence of impurity oxygen on the structure of titanium hydrides and their structural stability over a broad range of concentrations and temperatures. Oxygen was introduced to TiH_x films by condensing titanium dihydride vapor in a vacuum of 10^{-7}Pa on glass substrates which had been mechanically and vacuum treated. The plates were ground, polished with diamond paste, etched in 1-2 percent HF, washed in acetone, alcohol and distilled water and dried in air. The substrates were then placed in a deposition chamber and degassified under a vacuum, heated to 723 K and bombarded with inert gas ions to regulate the quantity of water adsorbed on the surface before deposition, thus regulating the quantity of dissolved oxygen. Electron microscope studies showed no signs of tetragonal FCC-lattice distortion as the films were cooled to about 120 K. It was thus demonstrated that the addition of about 1 at. percent oxygen had a stabilizing effect on the FCC γ-phase structure. References 10: 7 Russian, 3 Western (2 in Russian translation).

UDC 539.213:539.52

Superplasticity of Amorphous Alloy

18420069j Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian
Vol 66 No 2, Aug 88 (manuscript received 29 Apr 87; in final form 15 Oct 87) pp 396-401

[Article by Yu. B. Levin, V. A. Likhachev and O. N. Senkov, Leningrad State University imeni A. A. Zhdanov]

[Abstract] Results are presented from the mechanical testing of the amorphous alloy $Co_{57}Ni_{10}Fe_5Si_{11}B_{17}$. The influence of crystallization during deformation on plastic flow characteristics is studied to further clarify the reason for superplastic behavior of the material. Plastic flow parameters were found to depend on the holding time of the specimens

before extension at the test temperature, increasing holding time corresponding to decreasing maximum elongation. Plasticity of the amorphous alloy was found to increase sharply simultaneously with significant changes in structural state. Superplastic deformation is accompanied by processes of structural relaxation and crystallization and accelerates the transition of the amorphous alloy to the crystalline state. The potential superplasticity resource of glass crystallizing by a dislocation mechanism is estimated at approximately 10^3 percent. It is difficult to estimate the specific contribution from this deformation mechanism, but its contribution allows the current concept of the structure of glass to provide a natural interpretation of its superplastic properties. References 17: 13 Russian, 4 Western.

Method for Obtaining Noncombustible Resin Insulating Materials

18420081b Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 1 Dec 88 p 4

[Article by G. Pankratyeva]

[Excerpt] Nikolay Aleksandrovich Khalturinskiy, head of the laboratory on polymer combustion of the USSR Academy of Sciences' Institute of Synthetic Polymer Materials, set fire to a rod made of epoxy resin. As is known, synthetic resins burn excellently. It takes only a spark to ignite them. No such ignition occurred in this case, contrary to expectations; a crackling sound was heard, and a heated piece of the rod flew off to one side.

The secret proved to lie in the rod's contents. It was literally stuffed with thousands of 'fire extinguishers' the size of a poppy seed. They were tiny polymer capsules containing a fireproofing liquid.

"Packing the resins with such capsules was not difficult, but how to preserve the materials' physical and mechanical properties in so doing?," said Khalturinskiy. "Perfecting a process took a considerable amount of time, but we can now make items produced from epoxy, phenol, carbonyl and other resins noncombustible. All that it necessary is to fill liquid resin with microcapsules, mix the viscous mass carefully, pour it into a mold and let it set."

Insulating materials for household appliances and other purposes are being produced from epoxy resins. Such materials are being employed more and more broadly in aircraft building and civil engineering. After all, synthetic resins have numerous advantages: they are simple to produce, lightweight and strong. Still another advantage has now appeared: they have become fireproof.

(A photograph of N.A. Khalturinskiy is given.)

Extra-Pure Substances Institute Created in Gorkiy

18420114 Moscow IZVESTIYA in Russian 30 Dec 88 p 2

[Article by A. Yershov, correspondent, Gorkiy]

[Text] An Institute of Chemistry of Highly Pure Substances has been created in Gorkiy. Such chemical products are needed for nuclear physics, semiconductor technology and optics, for example.

"About 10 million different substances are now known in the world," related academician G. Devyatykh, director of the institute. "The Soviet chemical industry is producing 12,000 items. If substances produced in small quantities by laboratories are added to this figure, the list increases to 60,000 items. Unfortunately, even this amount is very small, considering present-day requirements."

Substances in which the content of impurities is a hundred-thousandth of a percent are now being obtained at the institute. In other words, the percentage of pure substance in such specimens is 99.99999. Specialists do not consider this figure the limit, however. Personnel of this young institute are now busy searching for ways of effectively purifying substances and developing materials and equipment which will not contaminate these substances.

UDC 669.721.5+669.781+661.665+677.53:539.34

Influence of Thermal Cycling on Deformation and Fracture Processes of Magnesium-Based Composite Materials Reinforced With High-Strength Fibers

18420049c Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 28 Jul 87) pp 47-51

[Article by G. G. Maksimovich, A. V. Filipovskiy, V. I. Mikheyev, A. I. Gordiyenko and I. V. Tarasenko, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] A study is made of the influence of thermal cycling on the structure of a composite material based on magnesium and reinforced with various types of fibers. The composite materials were created by high temperature compression of packets assembled of monolayers reinforced in the same direction. Reinforcing fibers were produced by vapor-gas precipitation of boron and silicon carbide on tungsten wire 12 μm in diameter. Volumetric content of fibers in the composite materials was 20 percent. Thermal cycling was performed by a mild regimen (20 to 150 to 20 to -196 to 20 to 150 to 20 to -196 to 20°C to...) and a more severe thermal shock regimen (150 to -196 to 150 to -196°C to...) with holding for 10 minutes at each temperature. A small number of thermal cycles resulted in damage to the fibers, while continued thermal cycling caused failure of the fibers and the matrix. After 20 thermal cycles, 8 percent of the fibers had cracks passing through the entire fiber without touching the tungsten core. After 30 cycles, 17 percent of the fibers had cracks and there were cracks in the matrix. Magnesium-steel materials were found to have greater thermal fatigue resistance than magnesium alloy reinforced with boron or silicon carbide fiber. The boron and silicon carbide fibers are themselves brittle and heterogeneous. References 5: 4 Russian, 1 Western.

UDC (546.562+537.312.62):53.098

Influence of Magnetic Field on Resistivity of Superconducting Ceramics LaSrCuO and YBaCuO

18420040d Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 1, Jul 88 (manuscript received 20 Nov 87) pp 189-192

[Article by V. L. Kozhevnikov, K. R. Krylov, M. V. Medvedev, A. I. Ponomarev, I. M. Tsidilkovskiy and S. M. Cheshnitskiy, Metal Physics Institute, Urals Department, USSR Academy of Sciences]

[Abstract] Galvanomagnetic effects were studied in the systems $Y_2Ba_3Cu_7O_{14}$, $YBa_2Cu_3O_7$, $La_{1.96}Sr_{0.04}CuO_4$ and $La_{1.9}Sr_{0.1}CuO_4$ at 1.7-300 K in magnetic fields of up to B=0.15 Tl. The results indicate achievement in the specimens of a resistive state, apparently resulting from a transition to the superconducting glass phase beginning at a certain magnetic field intensity. References 5: 2 Russian, 3 Western.

UDC 621.762.4:669.12:620.178

Influence of Iron Powder Type and Hot Stamping Conditions on Impact Toughness of Blanks

18420074a Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 27 Oct 86) pp 28-33

[Article by S. A. Firstov, Yu. N. Podrezov, A. G. Zherdin, A. A. Laptev, E. Ch. Pioro, V. M. Mizyuk and N. Ch. Pioro, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] A study is made of the influence of initial powder type and hot stamping conditions on the variation of impact toughness as a function of temperature in stamped blanks. Five types of iron powder were studied, including one West German and one Swedish type. Process conditions differed in the method used to prevent internal oxidation: vacuum hot stamping and stamping in air at room or elevated temperature with subsequent hot stamping in air to close pores. Impact toughness tests were performed on notched specimens, some of which were annealed. Hot stamping conditions were found not to influence absolute impact toughness values or experimental curve shape. Initial powder type did have a significant influence on impact toughness, particularly in annealed specimens. The West German powders, with lower interstitial impurity and oxygen content and lower porosity following pressing, had much greater impact toughness. References 7: all Russian.

UDC 621.762:621.365.5

Kinetics of Heating of Structural Parts Made of Ferromagnetic Powders During Induction Sintering

18420074b Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 13 May 87) pp 49-53

[Article by L. Sh. Bulatova, All-Union High-Frequency Currents Scientific-Research and Planning-Design Institute]

[Abstract] A study was made of the kinetics of heating of cold-pressed ring parts in a high frequency magnetic field. The variation of temperature and current in the parts, made of 97-98 percent iron powder, was studied as a function of time. A model of the process of conduction is presented, assuming that a conducting bridge is formed through the oxide films of two particles in contact. The electromagnetic structure of a powder part is assumed to consist of a set of resistive and inductive contacts distributed within the contour of the induced emf. Heating occurs in three stages, including an incubation period, a period of variable heating kinetics, and a period of relatively constant current extending up to the sintering point. References 10: 7 Russian, 3 Western (in Russian translation).

UDC 539.219.1;621.763

Formation of Porosity Upon Crystallization of Filament-Reinforced Gas-Saturated Melt

18420074c Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 25 Jun 87) pp 64-69

[Article by A. S. Dzyuba and M. Yu. Gandel, Kharkov University]

[Abstract] A study is made of the shadow effect observed upon crystallization of a gas-saturated melt reinforced with dispersed particles. When a reinforcing particle crosses the crystallization front of the melt, a zone free of gas bubbles is formed behind the reinforcing particle in the direction of movement of the crystallization front. The width of this zone, or shadow, depends on the speed of crystallization, the diffusion coefficient, the distribution of impurities and the saturation necessary for formation of gas bubbles. The shadows are formed in areas near reinforcing filaments with greater heat conductivity than that of the matrix. The distribution of gas porosity in composites can be controlled by changing the mutual orientation of the crystallization front and the reinforcing filaments. References 7: 6 Russian, 1 Western (in Russian translation).

UDC 669.018.95:621.763

Study of Hybrid Boron-Aluminum Composite

18420074d Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 5 May 87) pp 81-83

[Article by L. R. Vishnyakov, V. P. Moroz and L. N. Tsypina, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] The use of knitted steel in addition to monolayers of boron fibers to reinforce a boron-aluminum composite increases fracture toughness and transverse strength. Three types of specimens with different mutual placement of steel nets and boron fibers were studied, with different relationships of the number of layers of boron-reinforced material per layer of steel-netting-reinforced material. Introduction of the net changed the fracture type in the specimens with notches. The steel fibers created a spatially regular structure in the boron-reinforced aluminum, hindering major crack propagation and increasing fracture toughness. References 6: 5 Russian, 1 Western (in Russian translation).

UDC 621.922.34:666.233

Interaction of Titanium and Zirconium Diborides With Silicate Melts

18420074e Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 28 Dec 86) pp 84-88

[Article by A. G. Dovgan, A. N. Vashchenko, A. D. Panasyuk and A. P. Umanskiy, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] A study is made of the interaction of titanium and zirconium diborides with not over 2-3 percent porosity with glasses of various chemical compositions. Adhesion was studied by the lying drop method in argon at 940-980°C, after which the phase composition and structure of the interface zone were determined on a transverse cross section. Introduction of B_2O_3 decreases the contact wetting angle, facilitating the flow of the glass over the surfaces of the borides by decreasing the surface tension of the liquid phase. The boundary between the boride and the glass has no transition zone. Introduction of lead oxide decreases the contact wetting angle and increases glass flow time. A mechanism is suggested for the interaction of the silicate melts with the diborides. Group IV refractory borides can be used as dispersion-hardening additives to superhard material composites with silicate binder used for the manufacture of cutting and grinding tools. References 9: all Russian.

UDC 661.665.1

Chemical and Kinetic Specifics of Oxidation of Chromium Carbide Powder

18420074f Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 29 Jan 87) pp 88-92

[Article by S. F. Korablev, A. V. Lysenko and S. I. Filipchenko, Superhard Materials Institute, Ukrainian Academy of Sciences]

[Abstract] The mechanism of the oxidation of Cr_3C_2 was studied using powders containing 86.3 percent Cr, 12.5 C_{tot} and 0.1 C_{free}, particle size 7-10 μm. The powder was primarily Cr_3C_2, with 5-7 percent lower carbides. Oxidation was studied by differential thermal analysis during programmed heating to 1773 K at 3.75-15 K/min in air. Oxidation occurs in several stages, from Cr_3C_2 to Cr_7C_3 to $Cr_{23}C_6$ to Cr_{met} to Cr_2O_3. This confirms the preference for interaction of carbon with oxygen and the formation of lower carbides upon oxidation of Cr_3C_2 reported in earlier works. References 9: 8 Russian, 1 Western (in Russian translation).

UDC 621.92:661

Residual Stresses After Grinding of Titanium and Steel by Disks With Solid Lubricant

18420074g Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 88 (manuscript received 2 Mar 87) pp 97-99

[Article by A. I. Bezykornov and A. A. Adamovskiy, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] A study is made of residual stresses in steel and titanium specimens after they are ground with standard organic-binder diamond disks and new diamond disks containing solid lubricants and the additional abrasive titanium carbide in the diamond-abrasive layer, as well as disks of white synthetic corundum and green silicon carbide containing molybdenum diselenide as the solid lubricant. The studies demonstrated that the use of the solid lubricant decreased the magnitude and depth of residual stresses. References 3: all Russian.

UDC 620.18:539.27

Nonthermal Recovery and Recrystallization in Irradiated Metals

18420028a Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul-Aug 88 (manuscript received 15 May 87) pp 27-30

[Article by V. T. Zabolotnyy, V. P. Babayev and K. P. Gurov, Moscow]

[Abstract] Annealing of a metal by ion bombardment is considered, recrystallization and recovery of physical properties being interpreted in terms of collision cascades and intracascade recombination rather than in terms of a thermal peak. These processes are known to occur at temperatures near absolute zero when initial bombardment with light ions is followed by additional bombardment with heavy ones, the dependence of the electrical resistivity on the bombardment dose being characterized by a dip with minimum electrical resistivity corresponding to change from one kind of ions to another. Quantitative analysis of these processes, with this departure from monotonicity taken into account, is based on changes in the concentration of point defects and on the volume of spontaneous Frenkel-pair recombination. Numerical calculations for copper, silver, and gold agree fairly closely with experimental data. References 12: 5 Russian, 7 Western (3 in Russian translation).

UDC 621.315.592

Effects of Diffraction on Formation of Surface Structures During Laser-Induced Recrystallization of Silicon Layers

18420028d Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul-Aug 88 (manuscript received 8 Apr 87) pp 84-91

[Article by A. V. Demchuk, N. I. Danilovich, V. A. Labunov and A. M. Pristrem, Minsk]

[Abstract] An experimental study involving silicon layers doped by ion implantation was made for the purpose of identifying the effects of diffraction of laser radiation by a diaphragm on the formation of surface structures during recrystallization induced by diaphragmed laser radiation. Plate specimens of a KDB-0.3 Si single crystal with (111) orientation were doped with Sb by implantation of 60 keV ions to a density of 10^{15} cm^{-2} and then treated with 50 ns long pulses of fundamental-frequency 1060 nm radiation from a Q-switched multimode Nd-glass laser. The density of radiation pulse energy on the silicon surface was varied over the 0.5-4 J/cm^2 range by means of neutral filters, the incident laser beam having been reduced from a 19/12 mm wide elliptical one to a rectangular with a 6x9 mm^2 cross-section by a massive diaphragm in front of the surface at a distance which was varied over the 7.3-3.0 mm range. Space modulation of the radiation intensity owing to diffraction by this diaphragm, its edges becoming pulverized in the process, was found to cause modulation of the melting front in a Si layer and formation of diffractional surface structures along with surface structures not directly related to diffraction. Formation of diffractional surface structures is attributable to crystallization at a rate which fluctuates in time. As the extent of space modulation of the radiation decreases, with increasing distance of the diaphragm from the surface, the role of thermocapillary effects produced by the gradient of surface tension across the molten zone becomes more significant so that eventually surface structures with a depthwise almost uniform melting front are formed and these structures become periodic ones in the region of tapering radiation intensity. It was necessary to shield the lower surface of the diaphragm with a quartz plate so as to prevent pulverized diaphragm metal from falling on the silicon surface, but the metal particles trapped by this plate contributed to diffraction of laser radiation. An analysis of the data indicates that modulation of the melting front along the boundary of the recrystallized zone is accurately described by the equation for the distribution of laser radiation intensity in a Fresnel diffraction pattern on an opaque half-plane, and that the threshold energy density for formation of diffractional surface structures decreases with decreasing distance of the diaphragm from the surface. References 10: 6 Russian, 4 Western (1 in Russian translation).

UDC 621.785.54:622.24.54

Absorption Coefficient of Coating-Metal System in Radiation Field of CO_2-Laser

18420028f Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul-Aug 88 (manuscript received 23 Feb 87) pp 102-106

[Article by A. A. Solovyev, Moscow]

[Abstract] An experimental study of metal hardening by treatment with an infrared laser was made, the metal surface being usually coated with a radiation absorbing film so as to minimize reflection and the effectiveness of such a treatment being largely dependent on the absorption coefficient of the coating-metal system. Considering that the absorption coefficient changes during the laser treatment process, owing to changes in the thermophysical properties of the material, measurements of this coefficient were made for a determination of its dependence on both the power density of incident radiation and the surface density of incident energy as well as on the coating thickness. Yellow Pb_3O_4, black C (soot), Fe_2O_3, ZnO, and black $Mn_3(PO_4)_2$ were selected as coating materials for St45 carbon steel. Cylindrical specimens of steel 30 mm long and 15 mm in diameter, with a surface roughness of 0.00125-0.00250 mm, were coated with 0.010-0.100 mm thick films. An LGN-702 CO_2-laser with an output power of 675 W was selected for hardening treatment, its beam being variably focused onto spots 1-4 mm in diameter and moved over the

target surface at a velocity which was varied over the 33-99 cm/s range. Measurements were made by the calorimetric method over a 24 h period under normal conditions, the absorption coefficient being thus determined accurately within plus or minus 5 percent. The results indicate that the absorption coefficient of these materials under these conditions decreases with increasing power density and energy density, but does not depend on the coating thickness and on the laser beam velocity within the given ranges. The most effective absorber material was found to be Pb_3O_4, its absorption coefficient reaching 0.87 at radiation power levels up to 1 kW/cm. References 3: All Russian.

UDC 535.211

Temperature Within Irradiation Zone During Laser-Induced Breakdown

18420028h Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul-Aug 88 (manuscript received 15 Oct 87) pp 141-143

[Article by S. G. Bychkov, S. V. Minkov, Ye. D. Glebov and Ye. A. Kutanov, Alma-Ata]

[Abstract] An experimental study was made concerning the laser-induced breakdown of composite materials with a polymer binder component such as the asbestos board and mycalex usually used for targets and shields, its purpose being to monitor the mechanism of breakdown kinetics on the basis of loss-of-mass and temperature measurements. Specimens of these materials were treated with an LG-25B continuous-wave CO_2-laser for 120 s long periods with the radiation power density varied over the 40-60 W/cm^2 range. Loss of mass was recorded with the aid of a mechanotron as primary transducer. The color temperature was recorded with a spectral-ratio pyrometer, an MBS-9 binocular microscope splitting the laser radiation into two channels and two FD-24K semiconductor photodiodes operating as current generators serving as radiation detectors. The results of these measurements reveal that loss of mass is caused by destruction and a gasification of the polymer binder, the narrow temperature range of its gasification making the color temperature independent of the radiation power density. References 5: 3 Russian, 2 Western (both in Russian translation).

UDC 621.315.592

Modification of Surface Morphology of Silicon Layers by Nanosecond Pulses of Laser Radiation

18420021b Moscow POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 8, Aug 88 (manuscript received 18 Aug 87) pp 84-88

[Article by A. V. Demchuk, N. I. Danilovich and V. A. Labunov, Minsk Radio Engineering Institute]

[Abstract] An experimental study was made concerning formation of a cellular structure on the surface of Si layers by nanosecond pulses of laser radiation. Single crystals of KDB-10 Si with (111) orientation in the form of bare plates, as well as such plates with a 450 nm thick surface layer of polycrystalline Si deposited by pyrolysis of silane at 600-650 deg C under pressure of 80 Pa and doped with phosphorus (2.10^{15} cm^{-3}) by ion (100 keV) implantation, were treated with radiation pulses of 50 ns duration from a Q-switched Nd-glass laser. A pulse of 1060 nm fundamental radiation and a pulse of 530 nm second-harmonic radiation were applied, the latter pulse having been produced by means of a $LiIO_3$ frequency-doubling and linearly polarizing crystal. The surface density of pulse energy was varied over the 1-11 J/cm^2 range by means of gauge filters. The surface after such a treatment were examined under a NEOPHOT-21 optical microscope and with an EMR-100 electron diffraction camera producing reflection patterns. The results indicate that a cellular structure is formed owning to nonuniform evaporation after surface melting at temperatures near the boiling point and attendant capillary effects, the evaporation rate being higher at the concave meniscus under lower surface tension and lower at a convex meniscus under higher surface tension. A theoretical analysis of the phenomenon, on the basis of a simplified model disregarding the hydrostatic pressure due to surface unevenness, confirms that formation of a regular cellular structure represents a transition to the state in which the free energy is minimum. References 4: 3 Russian, 1 Western.

Explosion Welding in Industry

Explosions That Yield Profits

18420015 Novosibirsk EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA in Russian No 7, Jul 88 pp 47-50

[Article by B. D. Tsemakhovich, doctor of technical sciences, Altay Polytechnical Institute imemi I. I. Polzunov, Barnaul; "Explosions That Yield Profits"]

[Text] At the Hydrodynamics Institute of the Siberian Department of the USSR Academy of Sciences, M. A. Lavrentyev and his school laid the scientific foundations for the theory of explosion welding. Serious theoretical and applied work has been done by his students—A. A. Deribas, V. M. Kudinov, and V. S. Sedykh, for example. The new technology is being used on an increasingly wider basis in our country and abroad. The most attractive aspects of the technology are, among other things, its relative simplicity and high efficiency, its ability to be used in the field with negligible capital outlays, its autonomy, and its freedom from the expensive electrical, gas, and compressed air systems that are traditional for any machine-building production line.

It has been proven theoretically that explosion welding can be used to produce bimetal blanks of unlimited size. Today this matter has been resolved through the efforts of a number of enterprises working in conjunction with institutions such as the Hydrodynamics Institute of the Siberian Department of the USSR Academy of Sciences, the Impuls Special Design-Technological Bureau, the ANITIM Scientific Production Association (Barnaul), the Altay and Volgograd polytechnical institutes, and the Electric Welding Institute imeni Ye. O. Paton of the UkSSR Academy of Sciences.

A technology for explosion cladding of large blanks of both simple and complex configuration has been developed and introduced at several power engineering and chemical machine-building enterprises working with the ANITIM Scientific Production Association. The Central Scientific Research Institute for Machine-Building Technology [TsNIITmash] provided the general scientific direction and coordination of the work. At its initiative, economically efficient objectives were determined, and the properties of the bimetal produced by explosion were studied.

The technology for explosion cladding of the rotor blades of hydroturbines for large hydroelectric power plants (GES) such as the Krasnoyarsk, Sayano-Shushenskiy, and Ust-Ilimsk GES was introduced at the Leningrad Metal Plant in 1967-77. The production cost of such hydroturbines, which are made of structural steels that have been cladded with a thin layer of stainless steel, was 3-4 times lower than that for those made entirely of stainless steel. There was virtually no loss in durability. The 15 years that these turbines have been in operation at the Krasnoyarsk GES have shown the considerable advantages they offer over blades protected from cavitation by other methods. Repair expenditures and downtimes for the machines have been reduced considerably.

The technology for using explosions to produce large bimetal blanks that weigh up to 10 tons was used at the Sibenergomash Production Association (Barnaul) for manufacturing the steam drum separators for the Far East's first nuclear power plant (AES) at Bilibino and provided a savings of nearly 1,000 rubles per ton of bimetal. A ton of bimetal produced by automatic submerged-arc surface build-up, with subsequent rolling, costs 1,500-1,840 rubles, whereas a ton produced with explosion welding costs only 400-500 rubles.

Good results have been achieved at Uralkhimmash, where explosion welding has been used to clad huge blanks (4 meters in diameter and weighing 40 tons) of tube sheets for reactors used in the production of ethylene oxide. The savings on each such blank reached 32,000 rubles, and the amount of stainless steel used was reduced by a factor of three. The plant has completely abandoned the use of welding tape, which is in short supply. For 15 years now, there has been a permanent explosion-welding section that clads parts that are important to chemical machine building.

What must the test site for the explosion welding be like? Let us arbitrarily divide the production of bimetal into two types by volume of manufacture: small-series or individual production (up to 1,000 tons of bimetal a year) and large-series production (greater than 1,000 tons a year). For the first type, the capital costs for creating a test site are negligible. As a rule, worked-out rock or sand quarries can be used. Personnel working in quarries are accustomed to explosion operations, and warning systems and systems for cordoning off areas have been set up. Several problems remain to be solved. One of the most complex and important problems involves the transportation of the blanks and finished bimetal and the acquisition of a crane truck. Another problem involves production personnel. Duty-shift (vakhtovaya) work is convenient for remote quarries. This requires crews of 8-10 men.

It is most efficient to schedule in the warm season, when the temperature is 10°C or higher. If conditions allow, the annual program for producing the bimetal should be planned for the summer. That is how Uralkhimmash structures its operation. The cold creates complications. If winter work is unavoidable, the simplest portable shelter must be put up. Portable airport heating units like the Sever are used for heating the blanks (the cost of a shelter for this unit is no more than 3,000 rubles, and it pays for itself quickly). The blank can be heated with another method—in a furnace at a plant. After the blank is heated to 140-160°C, it is covered with asbestos cloth. Such heating is sufficient for normal explosion welding of a large blank, even if the test site is 40-60 km from the plant.

A well-equipped test site is required for high-volume series production of bimetal. The radius of the explosion-proof zone and the discharge area [ploshchad otvoda] are determined on the basis of nomenclature and the number of the blanks. The discharge area can be four times as small if the explosion zone is recessed in the ground, protective embankments are used, or an explosion chamber is built. The lion's share of the capital costs go to construction of roads to the test site.

If a local explosives warehouse of the Soyuzvzryvprom trust cannot be used, a warehouse must be set up. Service areas no smaller than 1,000 square meters are needed for personal facilities, an ultrasound monitoring laboratory, a workshop, a garage, and storage of materials. Such a test site can cost 5-15 million rubles. But with the manufacture of 5,000 tons of bimetal a year, it pays for itself in 2-3 years.

Nevertheless, the production process of explosion welding is making its way into industry slowly, undeservedly so. We are paying exorbitant prices for bimetal abroad, even though we could produce it in our country at minimal expense. And why? In my opinion, the reason lies in the old, administrative methods of managing industry that are hanging on to the end, in the stress on "production volume" in the evaluation of the operation of enterprises, and in the "cost-is-no-object" prices for products. In a moment of frankness, the chief engineer of one large Leningrad enterprise, resisting with all his might the expansion of the use of explosion welding, told me that he would not implement a technology that lowers commodity output to thousands of rubles per ton. He advised me to somehow raise the production cost of the bimetal!

A plant's rejection of the advanced technology is often motivated by such things as the inconvenience of work with explosion welding in the field, dependence on weather, the poor condition of roads, and difficulties that arise with portable hoisting and transportation equipment. There is some truth to this. But after all, economic results take care of everything in the final analysis, and they are unambiguous; every year, the economy loses tens of millions of rubles on obsolete, expensive technologies for manufacturing bimetal and on its import.

Multilayered Apathy

18420015 Novosibirsk EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA in Russian No 7, Jul 88 pp 50-54

[Article by E. B. Golland, candidate of technical sciences, and Ye. L. Lysaya, EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA (EKO) correspondent, both of whom interviewed Professor A. A. Deribas, doctor of physical and mathematical sciences, chief of the Special Design- Technological Bureau for Hydropulse Equipment of the Siberian Department of the USSR Academy of Sciences, and Lenin Prize winner; "Multilayered Apathy"; first paragraph is EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA introduction]

[Text] **At the request of the EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA editorial staff, Professor A. A. DERIBAS—doctor of physical and mathematical sciences, chief of the Special Design-Technological Bureau for Hydropulse Equipment of the Siberian Department of the USSR Academy of Sciences, and Lenin Prize winner—comments on the problem involving the extent of the use of explosion welding.**

A. A. Deribas: The author of the article "Explosions That Yield Profits" is absolutely right about the fact that the chief obstacles to the widespread introduction of this new technology are organizational and economic factors. Yes, enterprises and sectors lose the notorious "production volume" when they use explosion welding. The economy, however, wins, specifically because the multilayered materials that are produced with explosion welding result in a big savings by reducing the use of the expensive, scarce material that makes up only a thin layer of coating.

The article examines a production process that is still comparatively safely implemented in our country for applying stainless steel on carbon steel. To get to the point, it represents a small proportion of the explosion welding that is practiced throughout the world. In the United States, 80 percent of the explosion welding is for the steel-titanium bimetal, 10 percent is for steel-zirconium and steel-tantalum bimetals, and 10 percent is for other composites. Why is the first category given such a preference? Because they are chemically stable materials without which chemical machine building would be entirely impossible, and explosion welding is the only method for producing such materials. The use of these bimetals is advantageous because of the multiple savings of expensive, scarce materials and the greater reliability and longer service life of the product. Our country still does not produce these bimetals by explosion.

EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA: Why not? Don't we have the technology, or is something hindering its use?

A. A. Deribas: The technology exists, and it has been tested in experimental industrial use. The demand for it is tremendous. Our chemists are buying equipment abroad. A paradoxical situation is developing: foreign firms buy titanium from us, produce the steel-titanium bimetal explosively, manufacture equipment, and then sell it to us.

Why in the world aren't we ourselves producing two-layer materials? Departmental barriers are blocking us, and they are difficult to overcome under an administrative system of management. The Ministry of Nonferrous Metallurgy extracts the titanium from the ore. The Ministry of the Aviation Industry rolls the titanium for its own equipment. The Ministry of Ferrous Metallurgy makes the steel. The Ministry of Chemical and Petroleum Machine Building needs multilayered materials to produce equipment which is used by the Ministry of the

Chemical Industry. A quarter of a century wouldn't be enough for everyone to reach an agreement. The Ministry of Ferrous Metallurgy says that it's not its problem. The Ministry of the Aviation Industry, as a consumer itself, manufactures the rolled titanium stock for itself and doesn't intend to supply it to other sectors. Nor does the Ministry of Nonferrous Metallurgy show any interest in setting up the production of rolled titanium stock. Meanwhile, the Ministry of the Chemical Industry wastes foreign exchange on imported equipment.

As an interested party, the chemists have tried to produce a steel-titanium bimetal. At the request of the NIIKhlorproyekt [expansion unknown], we used explosion welding to produce an experimental batch of this metal. The experimental samples came out all right. But the Ministry of the Chemical Industry doesn't even have any more titanium for further work. And generally speaking, in my opinion, this problem should be solved in chemical machine-building: they already have the experience there in producing other bimetals with explosion welding, which B. D. Tsemakhovich points out convincingly.

EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA: Where have we developed explosion welding more successfully? In what sectors?

A. A. Deribas: Mostly in joining structural and stainless steels with the production of coatings on two sides. But we produce three times less of even that composite than does the United States. The Ministry of Ferrous Metallurgy is in no hurry to produce the trimetal if only because a similar material is produced in our country with pack rolling. And the fact that expensive in situ-cast stainless steel is used to protect against corrosion, when explosion welding could be used to apply only a coating made of it, doesn't bother the people working in the ministries. It is advantageous to consumer-enterprises as well as to manufacturers to use pure "stainless," because "production volume" is reached more rapidly. Producers fear that wide use of a steel-stainless bimetal for many industries will, in general, "shut down" the delivery of rolled stainless stock. One manager told me that quite openly.

Immense possibilities and indeed the need for multilayered materials exist in the Ministry of Tractor and Agricultural Machine Building. These materials are well suited for the plows and self-sharpening tillers used to turn the soil. A tiller made of a composite can last 100 times longer than an ordinary tiller. Just consider the savings that are possible on spare parts! The special design bureau for agricultural machine building at the Novosibirsk Sibselmash Production Association has been negotiating with us for many years. But every time the conversation gets to the need to specify multilayered materials in the design of new machines, the design bureau becomes afraid to dot the final "i," thinking that it needs to make the wear-resistant working parts of the soil-tilling machines without using scarce materials. Unfortunately, you can't make something good out of bad materials.

I would like to mention yet another area—hardening excavator teeth with explosion welding. In our country, almost half of the high-manganese G-2 steel made is used for excavator teeth. The amount of rock being mined is growing, as are the expenditures of metal used to replace worn-out teeth. Hardening excavator teeth with explosion welding can increase durability and produce a savings of nearly 700 million rubles a year. By the way, we are the only country in the world to have developed a technology for hardening teeth with explosion welding.

Explosion welding is used a little in steel-copper bimetals in the Novosibirsk Sibelektroterm Production Association. That association uses rolled plate copper more than any other association in the country, although maybe it wouldn't make a single part of in situ-cast copper if our technology were widely used. However, it's just marking time.

The technology for producing steel-brass bimetal for plain bearings is faring only slightly better. The Novosibirsk Siblitmash Plant is using it successfully. Plain bearings are usually made of bronze and babbitt. A steel-brass bimetal yields great savings on scarce nonferrous metals.

Recently, we tested bearings made of an explosively welded steel-aluminum bimetal and used for high-power diesel engines. That technology has a future, because the Ministry of Railways is interested in it. The ministry can save 20 million rubles a year as a result of reduced expenditures of spare parts for locomotive diesels. At the same time, one repair in the life cycle of the diesels will be cut out. This material can also be useful for marine diesels. It would pay the Ministry of the Shipbuilding Industry to take a look at it.

EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA: Ten years ago, explosion technology in metal working was used mostly for hardening the cores of railroad switches. How much has this use of the technology expanded since then?

A. A. Deribas: It is almost at the same level: 30 percent of the cores are hardened explosively.

EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA: Well, what has prevented wider use of the technology? After all, special machinery was developed for it at the Novosibirsk Switch Plant.

A. A. Deribas: The future of hardening switch cores was linked to a rise in speeds at which ordinary cores would be unable to last for very long. The speeds of railroad transport, however, did not increase. Moreover, in some places they dropped. I don't want to spend much time on

this special transportation problem, which is associated with things like a lack of stations, secondary tracks, etc. However, with no rise in speeds, there's no great demand for hardening of switches. And so the use of the technology remains at the same level.

Now someone in the Ministry of Railways thinks that the Novosibirsk Switch Plant should stop hardening switch cores and start producing locomotive diesel engine bearings made of a steel-aluminum composite, based on the fact that the enterprise has a great deal of experience in the use of the explosion technology. If the sector takes that route, it will be making a big mistake. We've got to look to the future. Track speeds will undoubtedly rise, since more attention is being devoted right now to the renovation of railroad transport. We've got to be ready when the problem of the durability of the switch cores becomes acute again. At the same time, we need to improve the quality of steel castings, on which the hardening effect of explosion welding also depends. The best steel used in a domestically produced switch is roughly twice as bad as American steel.

EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA: The development of fundamentally new technologies also depends on what form they're in when science hands them over to industry and how ready they are for use in industrial conditions. What does your Special Design Bureau for Hydropulse Equipment suggest to industry, how do you collaborate with the consumers?

A. A. Deribas: Almost all our efforts have made it to the stage of industrial technology. We provide the customers with documentation on the production process, equipment designs, and, now and then, the equipment itself or its most complex components. There can't be any obstacles here to the assimilation of explosion technologies for metal working. The main difficulties lie in the legacy of the old economic mechanism, in the still insufficient interest on the part of enterprises to introduce new, efficient technologies, and in the lack of agreement between the plans and actions of ministries. I think that the widespread introduction of technical innovations that result in big savings for the national economy and that have intersectorial importance should be addressed by the USSR State Committee for Science and Technology, USSR Gosplan, and the Machine-Building Bureau of the USSR Council of Ministers and should be supported by priority state orders that are profitable for the enterprises, favorable financing, and reliable material-technical supply.

Present-day multilayered materials are a very important factor in the developing of fundamentally new technologies, in conserving scarce metals, and in making equipment reliable and long-lasting. It is no accident that national programs are being created in many countries of the world for developing the production of new materials. They require special attention in our country, too.

UDC 621.791.927.5

Highly Productive Method of Plasma-Arc Hard Facing With Preheated Filler Wire

18420029a Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 5-6

[Article by O. I. Steklov, doctor of technical sciences, A. V. Alekseyev, candidate of technical sciences, O. A. Aleksandrov, engineer, V. I. Smirnov, engineer, and L. V. Ovcharenko, engineer, Moscow Petrochemical and Gas Industry Institute imeni I. M. Gubkin]

[Abstract] An experimental study of plasma-arc hard facing with a preheated filler wire was made, its purpose being to determine the technological characteristics of this welding process and particularly its productivity. Plates of 10Cr2MnNiMo alloy steel, 50 mm thick and 200x250 mm^2 large, were hard faced by this method with 3 or 4 mm wire of 05Cr20Ni9VNbSi alloy steel using a main plasmatron and an auxiliary plasmatron energized from three power supplies with the filler wire as the other second electrode. The plasma-generating gas was Ar; the shielding gas was a mixture of Ar and 8-10 percent H_2. The optimum process conditions were found to be a 300-315 A main arc-to-plate current, a 280-300 A auxiliary heating current, and a 50-200 A wire current with both arcs having either forward or reverse polarities, a facing rate of 8 m/h with 120 reciprocating strokes of 50 mm amplitude per minute, a 2-3 dm^3/min rate of plasma-generating gas, and a 5-6 dm^3/min rate of shielding gas. The production rate under these condition reached 23 kg/h with 3 mm wire and 33 kg/h with 4 mm wire. Residual stresses were relieved by heat treatment at 690 deg C for 12 h with subsequent cooling in the furnace. X-ray spectral microanalysis revealed an up to 5 percent interdiffusion of base metal and filler metal, within a 0.020-0.030 mm thick layer, and thus a much better end product than attainable by other methods of hard facing. The hardness after heat treatment was found to be maximum below the surface, near the fusion boundary, according to microhardness measurements with a 1 N load. This was confirmed by chemical analysis, which revealed a 1 mm deep decarburization zone in the parent metal. Metallographic examination revealed a nonoriented fine-grain austenitic-ferritic structure. References 2: both Western.

UDC 621.791.93:669.018.25

Characteristics of Mechanized Electroslag Hard Facing With Ribbon Electrode

18420029b Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 6-7

[Article by O. S. Volobuyev, engineer, Central Scientific Research Institute of Machine-Building Technology Scientific-Production Association]

[Abstract] An experimental study of electroslag hard facing with only one ribbon electrode was made, use of two such electrodes being much more effective generally

but not practical for small areas. Plates of St3 carbon steel were hard faced by this process with a 0.5 mm thick and 50 mm thick and 50 mm wide welding ribbon of Sv-07Cr25Ni13 alloy steel, using FTs-18 flux (CaO-CaF_2-Al_2O_3-SiO_2), which is characterized by sufficiently low viscosity and high electrical conductivity. The process parameters were varied: voltage over the 24-36 V range, current over the 500-1300 A range, and facing rate over the 8-14 m/h range. An analysis of the data reveals that the fraction of base metal in the deposit, which should be minimum, as well as the stability of the process will depend on the welding current and on the welding rate. The optimum current is 900-1000 A, but the range can be widened by lowering the welding rate, and the voltage should be lower than 28 V. References 2: both Russian.

UDC 621.791.052:620.17:669.296

Mechanical Characteristics of Welded Joints of Zirconium Alloys

18420029c Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 9-12

[Article by Yu. A. Grigorovich, candidate of technical sciences, V. B. Chizhov, engineer, V. N. Meshcheryakov, candidate of technical sciences, and S. T. Dobrovolskiy, engineer, Institute of Metallurgy imeni A. A. Baykov]

[Abstract] An electric-arc welding study of six Zr alloys (1 percent Nb, 2.5 pct Nb, 0.5 percent Fe plus 1 percent Sn, 0.5 percent Fe plus 1 percent Sn plus 1 percent Nb, zircalloy-2, 1 percent Sn plus 3 percent Nb) was made, its purpose being to determine the mechanical characteristics of the seams as well as of the base metal in the heat-affected zone. Plates 1x10 mm^2 in cross-section and 36 mm long were welded together under vacuum at a rate of 15 m/h, their temperature being varied over the 20-400 deg C range. Specimens 3.2x12 mm^2 in cross-section and 100 mm long were heated with electric current to 1500 deg C uniformly over a 20 mm long segment and then cooled at rates of 5-40 deg/s with an argon jet, 200 deg/s with oil, and 400 deg/s with water. Specimens of joints 1 mm thick and of various appropriate widths were tested mechanically for hardness, tensile strength, percentage elongation as indicator of plasticity, and maximum bending angle at 20 deg C before and after annealing at 580 deg C for 3 h, for impact strength by the Mesnager method at 20 deg C before and after annealing at 650 deg C for 5 h (except joints of 2.5 percent Nb alloy, annealed at 580 deg C for 24 h), and electrically for resistivity at 77 K. Annealing was found to improve the plasticity of the joints of some but not all alloys and to decrease their electrical resistivity. References 7: 5 Russian, 2 Western (1 in Russian translation).

UDC 621.791.052:539.4

Effect of Weld Filler on Higher Resistance to Fracture-Cracking Within Zone of Martensitic Base Steel and Austenitic Seam Steel Mixing

18420029d Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 12-14

[Article by B. F. Yakushin, candidate of technical sciences, B. V. Paramonov, engineer, and Ya. A. Sobolev, candidate of technical sciences, Moscow Higher Technical School imeni N. E. Bauman]

[Abstract] An experimental study of automatic electric-arc welding of 30Ni4MoCuV plate steel was made for the purpose of determining the effectiveness of a weld filler in reducing the cold shortness of the joint. Multipass welding was done with a 5 mm electrode wire of SV-08Cr20Ni9Mn7Ti alloys steel and AN-22 flux. The process parameters were varied: voltage over the 35-40 V range, welding current over the 550-750 a range and welding rate over the 12-20 m/h range. A filler wire of the same alloy steel, 2 mm in diameter and 1000-1200 deg C hot, was fed into the pool at rates 30-50 percent lower than the consumable electrode wire. The results of microhardness measurements, microstructural examination with phase analysis, and chemical analysis for distribution of alloying elements indicate that the filler does appreciably narrow the zone of martensitic base metal and austenitic seam metal mixing from 0.050-0.060 mm without filler to 0.020-0.025 mm and levels the microhardness peak within this zone. Welding with an electrode wire of Sv-10Cr16Ni25N_2Mo6 alloy steel containing more nickel was found to be only 0.020-0.030 mm wide without use of filler, addition of filler narrowing it down to 0.010-0.015 mm. Addition of this filler wire at a rate 30 percent lower than the feed rate of electrode wire during conventional welding at a rate of 19.16 m/h with a voltage of 30 V and a current of 600 A was found to lower the fraction of base metal within the mixing zone by 50 percent, after having caused 15-20 percent less base metal to melt, and to accordingly improve the resistance to cracking within this zone. References 2: 1 Russian, 1 Western.

UDC 621.791.753.9

Multielectrode Head for Welding Circular Seams Under Co_2-Gas Shield

18420029e Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 p 21

[Article by A. A. Bugayets, engineer, M. V. Orlov, engineer, and S. A. Suschenko, candidate of technical sciences, Ukrainian Polytechnic Correspondence Institute imeni I. Z. Sokolov, Kharkov]

[Abstract] A multielectrode head has been designed and built for welding circular horizontal seams, this head being mounted on a platform horizontally movable along the vertically movable arm of a column rotatable

through 270 deg. Up to 10 electrode wires 1.2-2.0 mm in diameter can be simultaneously fed at a rate variable over the 6-120 m/h range while the head is rotated at a speed variable over the 0.8-5.3 rps range. Welding is done under a shield of CO_2 gas, its feed rate being variable from 60 dm^3/h for welding with only one electrode to 900 dm^3/h for welding with all 10. Circular seams 600-2000 mm in diameter can be welded at a rate of 30-35 m/h, with all 10 electrodes (1.2 mm wires) and a current of 1100-1200 A at a voltage of 35-37 V. Welding with such a head saves 91,600 rubles annually. The cost of a complete unit including two 0.5 kW electric drive motors is 1500 rubles.

UDC 621.791.75.03(088.8):621.642.1

Welding Unit for Longitudinal Seams on Thin Boiler Shells

18420029f Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 p 23

[Article by V. V. Kalyuzhnyy, engineer, Voroshilovgrad Machine-Building Institute]

[Abstract] A welding unit for the manufacture of thin boiler shells is proposed which offers a great advantage over the conventional units with clamping keyboard used for welding flexible structures, namely fewer movable parts and thus higher reliability as well as easier maintenance and repair. Instead of a clamping keyboard, this unit has pneumatic tubes which seal the flux in a flexible cradle while pressing together the edges of parts to be joined. The number of moving parts is reduced to a minimum and the unit can be built without special materials in any metal-machining plant at no particular cost. It consists essentially of a horizontal channel-arm carrying the flexible cradle with flux and a horizontal pressing plate with two guide bars, both attached to a bushing inside a rigid column.

UDC 621.791.92:621.373.826

Performance of Laser Equipment in Hard Facing and Heat Treatment

18420029g Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 25-26

[Article by Ye. M. Birger, candidate of technical sciences, and V. Ye. Arkhipov, candidate of technical sciences, All-Union Scientific-Production Association Remdetal]

[Abstract] Lasers are increasingly used by the equipment maintenance and repair industry for reconstitution of worn moving parts, especially of intricately shaped ones requiring adequate precision, by hard facing or heat treatment. One of them is the LGN-702 Co_2-laser with a power rating of 800 W, performing very well in reprocessing cams and shafts of small hydraulic and fuel feed mechanisms as well as of large drives in tractors and mowers. This laser can be installed for hard facing or for heat treatment or in a universal version for both. A new generation of 2-5 kW lasers will have a broader range of applications. In the meantime, the Latus-31 laser with a power rating of 1.2 kW performs as well as the LGN-702 despite its more complex construction. On the basis of a 1000 h service life, such a laser saves on the average up to 35,000 rubles annually and its typical cost of 24,000 rubles can be amortized within 1 year.

UDC 621.791.72:621.375.826

Laser-Beam Welding of Filter With Insert Made of 12Cr18Ni10Ti Steel

18420029h Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 p 29

[Article by N. Yu. Grechkina, engineer, S. F. Moryashchev, engineer, V. M. Nesterenko, engineer, and E. P. Pervukhin, engineer]

[Abstract] The problem of welding together a miniature structure made of 12Cr18Ni10Ti steel, namely an 80 mm long cylindrical filter and a 0.5 mm thick frame, was solved by use of a laser beam. This method produced a seam of adequate strength without filling adjacent meshes, which happens during arc welding. On the basis of bend tests by the three-point method, fracture occurring consistently near the fusion line, the strength of such welded joints was 59-168 MPa while the strength of the base metal remained within the 64-168 MPa range. References 3: all Russian.

UDC 621.791.72:621.375.826

Comparative Evaluation of Heat Utilization Efficiency During Laser-Beam Welding

18420029i Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 31-32

[Article by S. G. Gornyy, candidate of technical sciences, V. A. Lopota, candidate of technical sciences, I. V. Matyushin, engineer, V. D. Redozubov, engineer, I. G. Rudoy, candidate of physical-mathematical sciences, A. M. Soroka, candidate of physical-mathematical sciences, and A. P. Chekmozov, engineer]

[Abstract] Welding with a continuous-wave laser beam and with a periodically pulsed one is comparatively evaluated with respect to thermal efficiency. This evaluation, based on calculations and measurements, reveals that the periodic-pulse mode of welding offers no advantage despite its higher thermal power, the reason being that the depth of the melting zone is smaller. Besides, both modes of laser-beam welding are limited by almost the same maximum permissible radiation intensity. References 9: all Russian.

UDC 621.791:658.34.2:628.83

More Extensive Use of Torches With Built-in Suction for Mechanized Welding

18420029j Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 42-43

[Letter to editor from L. A. Geshlin, engineer, Donetsk Department of the Special Design Bureau of the Kiev Scientific Research Institute of Labor Hygiene and Occupational Diseases]

[Abstract] A plea is made for more extensive use of torches with built-in suction for removal of welding aerosol from the action zone during mechanized welding. Convective ventilation with adequate exhaust facilities is still necessary inasmuch as built-in suction is not 100 percent effective. Torches developed during the past 5 years and tested in heavy-machinery manufacturing plants are already 70-90 percent effective. They have been designed for welding with 0.8-1.2 mm or 2.0-2.5 mm electrode wire and with current conductors either built into the aspiratory sleeve or running separately along it and are air-cooled so that the temperature at the welder's hands remains within the 22-30 deg C range.

UDC [621.791.052:669.715]:539.4

Formation of Hot Cracks During Welding of Aluminum and Its Alloys

18420059a Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 22 Jan 87; in final form 19 May 87) pp 9-14

[Article by M. A. Abralov, doctor of technical sciences, and R. U. Abdurakhmanov, candidate of technical sciences, Tashkent Polytechnical Institute]

[Abstract] Hot cracks formed in aluminum alloys are identified in the literature as crystallization cracks, the moment of their formation not being fully established due in part to the impossibility of direct observation of the processes of the development and growth of hot cracks under welding conditions. It is the task of this article to investigate fracture between crystals by microcinematography of the liquid bath and crystallizing metal. Studies were performed on high purity aluminum A99, technical aluminum A7, and the alloys AD31, AMts, AMg6, 1201 and 1420. It is found that hot cracks in aluminum develop at the boundaries of secondary crystals. Forced extension of specimens causes plastic deformations in the cooling metal. The temperature interval for the formation of hot cracks in aluminum alloys is 30-80°C below the true solidus temperature, significantly broader than in pure aluminum, while the critical deformation rate of aluminum alloys causing the formation of hot cracks is significantly lower than in pure aluminum. Formation of hot cracks is preceded by significant local plastic deformation of the boundary zones of both primary crystals and dendrites. The fracture process is therefore viscous in microscopic volumes, quasibrittle in the macroscopic scale. Hot cracks in aluminum alloys are formed not due to low plasticity of the alloys, but rather due to localization of deformations in narrow boundary areas following exhaustion of the plastic properties in the boundary zones of primary crystals and dendrites. References 11: 10 Russian, 1 Western.

UDC [621.791.754'293.052:669.295]:620.18:620.193.2

Influence of Structural Heterogeneity on Corrosion Resistance of Titanium Alloy Welded Joints

18420059b Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 24 Dec 86) pp 22-28

[Article by V. N. Zamkov, doctor of technical sciences, V. B. Volkov, V. A. Dymchenko, L. M. Onopriyenko and G. Ye. Boyeva, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the influence of structural heterogeneity on corrosion rate, stress corrosion and electrochemical properties of welded joints in type VT1-0 technical titanium and the alloys PT3V, VT5-1 and OT4. Corrosion testing was performed in 5 percent hydrochloric acid at 50°C for 100 hours, 25 percent citric acid at the boiling point for 300 hours, concentrated solutions of formic and acetic acids for 275 and 645 hours at the boiling point, and in a solution containing 160 g/l H_2SO_4 with and without 43 g/l Cu^{2+} ions as $CuSO_4 \cdot 5H_2O$ at 50, 55 and 60°C for 100 hours in the sulfate and 200 hours in sulfate plus copper. The influence of structural heterogeneity was found to depend on the properties of the corrosive medium and of the alloy. Annealing of welded joints to equalize grain size decreases or eliminates nonuniformity of corrosion damage but increases corrosion rate. Corrosion resistance under stress depends primarily on the composition of the titanium alloy. Corrosion was very rapid in methyl alcohol containing 0.4 percent HCl. Decreasing structural heterogeneity by annealing, particularly in a vacuum, makes the electrochemical characteristics of the base metal, zone of thermal influence and seam metal more similar. References 4: all Russian.

UDC [621.791.011:669.715].001.24

Weldability of Medium Aluminum-Zinc-Magnesium Alloy

18420059c Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 12 Jan 87) pp 29-32

[Article by V. G. Ignatyev, candidate of technical sciences, D. M. Rabkin, doctor of technical sciences, L. N. Antonenko, V. V. Sayenko and N. N. Fortunatova, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences; V. V. Zakharov, candidate of technical sciences, All-Union Light Alloys Institute]

[Abstract] An estimate is presented of the weldability of aluminum alloys 1915, 1925 and 1935 with a total content of zinc and magnesium less than 5.5 percent, as

a function of the content of all major alloying elements and impurities, as well as of zirconium, chromium, copper and nickel, which are used as modifiers or corrosion stabilizers. Strips measuring 100*3 mm in cross-section were hardened in the press and cut into 200 mm long specimens, naturally aged for 2 months then butt welded along the 100 mm edge by automatic argon-arc welding using a tungsten electrode. The welded joints were mechanically tested after 1 month of natural aging. The properties of the base metal and welded joints were found to be worse with increasing total content of iron, silicon and copper. However, the use of high-purity aluminum alloys eliminates the possibility of using secondary raw materials, thus increasing the cost of weldable alloys and decreasing production quantities. Production of two purity levels of each alloy is suggested, one for welding, the other for the manufacture of products with riveted, bolt and moderately loaded welded joints. References 7: 6 Russian, 1 Western.

UDC [621.791.75:669.15-194.2]:536.2

Monitoring Heat Conditions During Welding of Softening Steels

18420059d Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 16 Jan 87; in final form 5 May 87) pp 33-35

[Article by B. F. Lebedev, doctor of technical sciences, A. N. Pachshin, candidate of technical sciences, and S. M. Dudko, engineer, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] The purpose of this work is to create a method of operational monitoring of the welding process and the mechanical properties of the zone of thermal influence in joints, particularly the impact toughness of this zone, under production conditions by means of heat probes. Equations are suggested for the specific welding energy and cooling time in the 800-500°C interval as functions of the maximum temperature reached in the zone of thermal influence, welding speed and thickness of the metal. Procedures are suggested by which welding machine operators can monitor the size of the zone of thermal influence to assure that the welded material will not loose strength. References 8: all Russian.

UDC [621.791.762.1+621.791.14]:621.753.5

Contact Resistance Butt Welding and Inertial Friction Welding of Metal-Cutting Tool Blanks

18420059e Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 20 Mar 87) pp 39-43

[Article by V. K. Lebedev, academician, Ukrainian Academy of Sciences, I. A. Bezprozvannyy and Yu. A. Mirgorod, engineers, R. M. Shirokovskiy and G. P. Sakhatskiy, candidates of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences; L. I. Ivanov, candidate of technical sciences, Dnepropetrovsk Metallurgical Institute]

[Abstract] A study is made to determine an effective method of welding metal-cutting tools 8-10 mm in diameter by inertial friction welding and contact butt resistance welding. Cylindrical 8 and 10 mm diameter specimens of R6M5 high-speed steel were welded by the two methods to cylindrical specimens of U7 carbon steel of the same diameter. It is found that for diameters of less than 10 mm, contact resistance welding is preferable, yielding good quality joints in tool blanks 3-10 mm in diameter. For specimens greater than 10 mm in diameter, inertial friction welding is better, producing good quality joints in blanks of this cross section while minimizing welding allowance and power consumption. References 6: all Russian.

UDC [621.793.14:669.255'26'71'794]:621.438-2:620.193.14

Durability of Gas Pump Installation Turbine Blades With Co-Cr-Al-Y Coatings

18420059f Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 12 Jan 87; in final form 9 Jul 87) pp 44-46

[Article by N. P. Vashchilo, candidate of technical sciences, K. Yu. Yakovchuk, engineer, and I. S. Malashenko, doctor of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences; O. E. Kodzayev, engineer, Soyuzgazifikatsiya Production Association, Moscow; V. A. Matveyev, A. P. Tsybin, and Ye. N. Chirkov, engineers, Soyuzgaztekhremont Special Design Bureau, Bryansk]

[Abstract] Continuing earlier studies of the condition of protective coatings in the Co-Cr-Al-Y system produced by electron-beam evaporation and vacuum condensation on the turbine blades of gas pumping installations, the authors studied blades of the alloy IN-738 in a high pressure turbine following use for 8900 hours, as well as restored guide vanes of Hastelloy-X following use for 4760 hours at a compressor station. The studies indicated that the guaranteed operating life of coatings with a composition, in percent, of 29-30 Cr, 6-7 Al and 0.2 Y, is at least 30,000 hours. The restored guide vanes can also be used for long periods of time, the operating life limited only by the thickness of the protective coating. The recommended coating for guide vanes is created by precipitation from the vapor phase in a single layer, using a cobalt-based coating, containing, in percent, 18-20 Ni, 22-24 Cr, 10-11 Al and 0.15-0.2 Y, thickness 60-90μm at the rim, with aging in a vacuum at 820°C for 15 hours. References 9: 5 Russian, 4 Western.

UDC [621.791.793.002:621.3.018.783.4]:669.15-194.2:620.18

Electric-Slag Welding of 09G2S Steel by Modulated Current With Cooling

18420059g Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 20 Jan 87; in final form 18 May 87) pp 53-54, 65

[Article by A. N. Khakimov, doctor of technical sciences, V. A. Zakharov, candidate of technical sciences, and N. G. Daryavash, engineer, MING imeni I. M. Gubkin; Ye. M. Basko, candidate of technical sciences, TsNIIPSK]

[Abstract] A study is made of the combined influence of modulated current and accompanying cooling parame-

ters on the structure and mechanical properties of welded joints in 60 mm thick type 09G2S steel. Electric slag welding was used in a combined technology following preliminary welding of the seam root by mechanized welding under flux. Welding by the normal technology, with accompanying cooling and by modulated current with cooling were used. The third version had the greatest influence on seam metal, since both current modulation and cooling influenced the growth of the crystals. This technology has been tested on the pilot plant scale at Volgogradneftemash Scientific-Production Association and is recommended for industrial use. It can reduce the consumption of electric power by approximately 20 percent, achieving an economic effect of 15.2 rubles per running meter of seam length. References 5: all Russian.

UDC [621.791.75.053.92:621.365.64]:007.52

Specialized Robot for Spot Contact-Arc Welding

18420059h Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 13 Nov 86) pp 61-65

[Article by V. A. Timchenko, A. I. Bondarenko, candidates of technical sciences, A. S. Likhoshva and V. N. Skorina, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences; G. N. Strekalov, engineer, Energostalproyekt Special Planning-Design and Technological Bureau]

[Abstract] A specialized robot with an adaptive control system capable of seeking the proper location for spot welding has been developed for spot contact-arc welding of structures such as power transmission line towers. The welding robot is initially positioned by traveling on rails to the approximate location for the next spot weld, then a system senses the true location of the pieces to be joined and the final position of the welding robot is adjusted by fine movements on the bed which is carried on the rails. The position of the pieces to be welded is determined by a tactile sensor with a disk feeler which detects the presence and location of the angle iron pieces to be welded. The use of such specialized robots with feelers to determine the initial point for welding permits mechanized-flow lines to be constructed for the manufacture of metal lattice structures, decreasing labor consumption and making the work easier. References 4: all Russian.

UDC 621.791.052:669.14:620.186.12

Tendency of 10KhSND Steel Welded Joint Superheated Zone Toward Local Plastic Deformation

18420059i Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 2 Jul 86; in final form 10 Feb 88) pp 71-72

[Article by M. A. Fedotova, engineer, and A. P. Ammosov, candidate of technical sciences, Physical Technical Problems of the North Institute, Yakutsk Affiliate, Siberian Department, USSR Academy of Sciences; V. G. Vasilyev-,candidate of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the plastic local deformation tendency of 10KhSND steel specimens when heated. Dilatometric measurements were performed using a high-speed dilatometer designed by the Electric Welding Institute. The greatest deformation was observed in sectors with the maximum ferrite content. Sectors with bainite structure were deformed least. The range of permissible cooling rates, 2.5 to 50°C per second, corresponded to the rates of cooling of 10KhSND structural steel during welding. The presence of a soft intermediate layer of ferrite segregations along the boundaries of the hardest bainite grains significantly facilitates local deformation of the material and consequently increases the plasticity of the welded joint heated zone. References 6: all Russian.

UDC 621.791.72.002:62-242.134

Improvement in Design of Welded-Cast Diesel Pistons Welded by Electron Beam Method

18420059j Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 88 (manuscript received 17 Jul 87) pp 74-75

[Article by A. A. Bondarev, candidate of technical sciences, and Ye. G. Ternovoy, engineer, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences; A. N. Shalay, candidate of technical sciences, Kiyevtraktorodetal Production Association]

[Abstract] Tests of D-160 diesel engine pistons at the Chelyabinsk Tractor Plant imeni V. I. Lenin have shown that the temperature at the edge of the combustion chamber in pistons welded by the electron beam method is 40-60°C lower than in pistons in which the cooling cavity was produced by means of salt rods. To prevent crack formation and simplify assembly and welding, a piston design was developed with a single circular seam around the side of the piston to seal the cooling cavity. An intermediate circular insert was installed in the cavity to improve cooling, then welded simultaneously with the cover to the body of the piston. An experimental batch of pistons was welded, mechanically worked and tested for 800 hours according to the state standards, which indicated that the electron-beam welded pistons maintained a temperature at the edge of the combustion chamber of 280°C and 210°C at the top compression ring, 20-30 and 10-15°C lower than the temperatures of pistons manufactured by the traditional method. No defects were found after 800 hours of test operation. References 13: 7 Russian, 6 Western (1 in Russian translation).

UDC 622.346.1.002.612

Estimating Quality of Chromium Ores in Mine Crop

18420033a Moscow GORNYY ZHURNAL in Russian No 8, Aug 88 pp 21-23

[Article by V. N. Shashkin, chief engineer, G. A. Yelpashev, chief geologist, and V. I. Parchenko, senior mining geologist, candidate of geological-mineralogical sciences, Don Basin Mining-Concentrating Combine, and A. P. Poddubnyy, candidate of geological-mineralogical sciences, All-Union Scientific Research and Engineering Institute of Mineral Deposit Drainage, Special Mining Projects, Mining Geology and Mine Surveying]

[Abstract] A procedure and an apparatus have been devised for estimating the amount of chromium ore in slurry samples without including extraneous material that distorts their contents. The sampler is a split vertical tube made of drill rod 42 mm in diameter with a conical countersink at the bottom end, held by a hinge-joined split cylindrical yoke and allowing a short column of slurry 32 mm in diameter to rise. Slurry is driven at a high velocity of 20-80 m/s by water-and-air stream from the well to the sampler and forms a flabellate trail around the later with a stagnation zone on the other side. A trail is sampled point-by-point and its content is analyzed for Cr_2O_3, FeO, SiO_2. The contents of several such trails are statistically evaluated, taking into account the randomness of ore distribution and also the well-sampler geometry.

UDC 338.45:622.3.002.237

Payment for Commercial Minerals and Prices of Raw Materials

18420033b Moscow GORNYY ZHURNAL in Russian No 8, Aug 88 pp 26-28

[Article by S. M. Ulanov, economist, USSR State Committee on Prices]

[Abstract] Setting prices of raw materials on the basis of the maximum costs the national economy can afford and standardizing payments for commercial minerals by the residual method on the basis of their specific use, namely by subtracting other payments and deductions from the total profit made by a mining enterprise as proposed by K. G. Gofman and M. B. Vitt (EKONOMICHESKAYA GAZETA No 37, 1987), is not consistent with the economics of mining. Instead, payments for raw materials ought to be and can be determined so as to solve at least two problems: 1) segregate that part of the total profit which does not depend on the productivity of a mining enterprise and thus does not contribute to variations of the income level of an enterprise, 2) ensure commensurability of incomes made by enterprises operating under different conditions. The problem of standardizing payments is therefore to be treated as the inverse problem of standardizing the cost of mining on the basis of an universal principle applicable to all enterprises. The polarity principle, formulated by Professor V. K. Shkatov, is appropriate here. It takes into account variance of mining performance indicators depending on the location of deposits as well as on the income of enterprises built into their prices. It differentiates payment rates, treating them as either positive or negative quantities. The principle is rational and admits optimization for most economical utilization of mineral resources, while eliminating the pricing problem. It is not rigid but subject to improvement and refinement. References 1: Russian.

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